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THE SOCIAL EFFECTS OF MASS PRODUCTION[1]

By Dr. DEXTER S. KIMBALL

DEAN OF THE COLLEGE OF ENGINEERING, CORNELL UNIVERSITY

IN the center of the theater district on Broadway, New York City, behind large plate glass windows there stood a short time since a modern cigarette-making plant. One machine, fed constantly with pulverized tobacco leaf and wrapping paper, ejects continuously a cigarette bar which is cut into standard lengths as it issues from the machine at the rate of 500 cigarettes a minute. A neighboring machine takes the cigarettes and automatically places them in packages, closes them and delivers the finished marketable product. The degree of skill required to operate the machine is small, though, of course, some one must fully understand the mechanism and be competent to make adjustments. At the other extreme of size, consider the automatic factory of the A. O. Smith Company of Milwaukee. This great machine literally takes in steel plates at one end and ejects finished automobile frames at the other at the rate of 8,000 daily. The machine, for such it virtually is, cost $10,000,000 and requires only 200 men to operate it. Probably 5,000 men would be required to produce the same result with ordinary processes. Here again, of course, there must be a certain number of skilled engineers who can adjust the machine, but the labor cost of actual operation is comparatively insignificant.

A survey of any progressive industry will reveal similar developments and constant progress toward the mechanization of its processes. Everywhere one finds the handicraftsman displaced by the machine and the semi-skilled operators, backed by the most lavish use of power the world has ever witnessed. In many instances the product is equal to or better than the

[1] Address of the vice-president and chairman of Section M—Engineering, American Association for the Advancement of Science, Atlantic City, December, 1932.

work of the artisan and in all cases the volume of product per worker is vastly greater than can be achieved by handicraft. Of course, there is nothing new *in principle* in these developments, which began with the first stone axe and culminated in the industrial revolution. Until that event the tool had always been an adjunct to the skill of the worker; but the developments of the industrial revolution made the worker an adjunct to the machine.

Since 1900 the mechanization of industry has proceeded at a rapid and apparently at an accelerated pace. As long as industry was prosperous and displaced workers, in some measure, could find work elsewhere, little attention was given to this tendency, though thoughtful writers have from time to time called attention to the problem. But the present depression has aroused more interest in the basic reasons for unemployment than any other in modern times, and for the first time technological unemployment, as this displacement of labor is called, appears as a vital issue and as a possible factor, in a large way, in the general problem of unemployment.

The most natural reaction on first observing productive processes such as have been described is one of concern for the skilled workers who may have been displaced by the new invention and a consequent belief that such advanced methods can not be conducive to the welfare of the workers. If, however, the observer should voice such fears probably he would be reminded of the great economic gains made by this country since modern manufacturing methods came into use and his attention would be directed to the high scale of living that the workers in this country enjoy, the inference being that modern methods of production can not in the long run be anything but helpful for all. While much can be said in support of both of these somewhat antipodal assertions, neither of them reveal the trials and tribulations through which many men have passed in building up our present level of existence, they throw no light upon the complex forces operating in the industrial field, nor do they even in a remote manner advise us as to whether the net trend is for good or evil.

Whenever an advanced process, such as those referred to in the foregoing, is set in motion, several economic changes at once become operative. The first is an increase in the capital investment and a further separation of the worker from the ownership of the tools of industry. This tendency is not connected directly with this present discussion, except that it has progressively closed certain avenues of escape open formerly to the worker under simpler industrial conditions. As industrial equipment has grown more complex and more expensive, the worker's industrial independence has decreased until to-day he is no longer an economic self-sufficient unit, but dependent largely upon capitalistic management for an opportunity to earn his daily bread. Consequently, the need of protective measures in his behalf increases daily.

The greatest and most immediate menace to the worker because of industrial progress is this displacement in favor of more highly developed machines in the hands of less skilled workers or "degradation of labor," as it has been called. In the early days of the industrial revolution in England the ruthless application of improved methods in the textile industries and the displacement of handicraft workers by machinery operated by children of tender years forms one of the darkest pictures in modern industrial history. Such direful conditions never prevailed in this country, even from the earliest days. Industry itself was in the making, the frontier was always accessible and a change from one calling to another not so difficult as at present. Even during the rapid expansion and development of industry in the latter half of the last century, technological unemployment was never a serious issue, though it had begun to raise its head. This is not to deny, of course, that at times and places much distress has occurred because of such displacement. Industrial progress is necessarily accompanied by change and apparently such change is necessarily accompanied by suffering on the part of some one. Progress, change and distress for some persons appear to be concomitant. The U. S. Census Report of 1900 mentions this tendency specifically as a menace to the wage-earner and predicts a doleful future for the wage-earning class in the following words:

> A factor that has a real tendency to lower the actual earnings of the wage earner in many industries is the displacement of the skilled operator by machinery which permits the substitution of a comparatively unskilled machine hand. This tendency is noticeable in many lines of industry. Its effects are twofold; to reduce the number of employees producing the same or an increased quantity of product and hence to lower the total wages of the group; and to reduce the average rate of wages because of the lower degree of skill required. The effect of the introduction and improvement of machinery upon the condition of the skilled artisan is an economic question of the greatest importance.

Here is analysis and prophecy, the accuracy of which will be discussed subsequently, after an examination of some other phases of the problem.

If this displacement of labor, as described in the foregoing, were the only effect of modern productive methods we should have found ourselves long ago in great difficulties. But improved machinery, while frequently displacing labor of a certain degree of skill, provides employment for workers of a lesser degree

of skill, and thereby "extends" the field of industry to workers who otherwise could take no part in modern manufacturing. Hence in the older callings that have been mechanized, shoes are no longer made by shoemakers, watches by watchmakers, or knives, forks and spoons by skilled cutlers and silversmiths, but by semi-skilled workers operating highly developed machines. More important still, these new methods and processes have made possible the building up of new enterprises of vast proportions, such as the sewing machine, the automobile, telephone, radio, refrigeration and other new industries, and which, but for modern methods, must have remained small in size with their products classed as luxuries. And these new mechanized industries in turn have given rise to supporting industries of great importance. Thus it is estimated that the automotive industry when busy gives direct employment to 800,000 workers and indirectly to 4,000,000 workers who supply equipment, raw materials, accessory parts, gasoline, etc. The plants of the Western Electric Company, which is the manufacturing arm of the American Telephone and Telegraph Company, have a normal capacity of over 50,000 workmen and the supporting industries must employ many thousands of workers. One wonders what this army of men would be doing if these new developments had not appeared.

The history of the development of these new factors in our existence should be noted, for it gives a clue to the character of the inventions which may be needed to hold the pace that has been set. The story of one is the story of all. First, there appears the period of invention and incredulity on the part of the public. It is only a few years ago that the electric motor was looked upon as an interesting toy, and the same was true of the telephone. A very few years ago the drivers of "horseless carriages" were viewed with mild amusement. Then comes the period when it is a luxury to possess one of the new devices. In the year 1880, for instance, it cost as high as $280 to have a private telephone. Finally, when the new device has proven its usefulness, mass production reduces the cost, and it becomes an economic necessity, the number in use depending sometimes, as in the case of the watch, almost solely upon the population. The sewing machine, the telephone, the automobile and other modern products have all justified their existence economically. It should also be noted that the driving power back of these modern methods is increased production and decreased costs. And it is a peculiar characteristic of these methods that as the quantity to be manufactured is increased, the unit costs can be decreased, which stimulates consumption, and this in turn reacts upon production, thus creating an ever-widening cycle of increasing production and decreasing costs until some limiting factor checks the movement. The results of this cycle are too well known to merit discussion, but it may be noted that in all probability the greatest value ever offered the public for every hour of labor expended is to be found in some of the moderate priced automobiles. How cheaply they may be produced time, only, will tell. The net result of modern methods, therefore, has been a vast increase in the quantity of manufactured goods and a remarkable decrease in the cost of them. It should be remembered that these methods have also been reflected in the basic industry, agriculture, and it would appear that the problem of production is fairly well solved, since at this moment we are producing more goods and more food than we can conveniently use, or rather more than we can intelligently distribute.

In résumé, therefore, as industry advances, some classes of workers are displaced, while at the same time other workers of lower degree of skill are given employment in callings hitherto closed to them. The displaced workers may find employment at the same economic level elsewhere, or they may be compelled to drop to the level of the new semi-skilled group. If the displaced workers are skilled in the machine building trades, they are usually absorbed by these callings, and the movement in general has been of advantage to the so-called "mechanic arts" group through the great development of the machine-construction industries. Other classes of workers have not been so fortunate, for it should be remembered that it is very difficult for a mature man of limited education to change his calling, to say nothing of the restrictions now imposed by trade unionism upon such changes. The statement so often made that displaced workers "find work elsewhere" is not always true, and if they do so it may be at an economic sacrifice. In time, of course, the displaced workers pass out of the picture so far as their old vocation is concerned, and the calling appears in a greatly modified form.

For the new groups that have been recruited, the conditions are usually the reverse. Given a small amount of training, they can be made more highly productive than formerly, they can render a greater service to society, and their remuneration in general is increased. That is, they may be, and generally are, elevated economically and as a natural result socially. The absorption of immigrant people and their descendants by the industries of New England and their economic and social elevation is too well known to need discussion, and the process still continues, not only there, but in every manufacturing center of this country.

Until quite recently, our industrial progress was viewed with considerable satisfaction. Our per capita

wealth has risen from $383 in 1850 to about $3,500 at the present time. Our national wealth has reached the unprecedented total of about $400,000,000,000 and our national income approximated $90,000,000,000, a most remarkable amount. Our scale of living exceeded anything in history, and despite the present depression, other nations, notably Germany and Russia, are eagerly studying our methods and adopting those that may help them to emulate our success. It appeared to many of us that we had really entered a new era and that we had in some measure solved the problem of living through high wages and a constant increase in the manufacturing cycle that has been described. The depression, therefore, came as a very painful reaction to many.

Economists in times past have usually looked for the causes of depression in the law of supply and demand, a change in the supply of gold or in some disturbance in international trade, all of which would be adjusted with time. But now for the first time a new and sharp question is raised concerning our manufacturing methods and equipment, and the fear is expressed that our industrial equipment is so efficient that permanent overproduction, for the markets available, has occurred and that consequently technological unemployment has become a permanent factor unless remedial efforts are put in force. Other critics contend that our methods of distributing the products and profits of industry are hopelessly antiquated, and that overproduction can not occur as long as there is poverty, want and ignorance. It is indeed a paradox to see storerooms filled with raw material, shoe factories equipped with the most efficient machinery man had ever produced, and workmen, anxious and willing to work, walking the streets almost without shoes for themselves or their families. It is not the province of this article to discuss this last contention, but it must be admitted that our present methods of distribution are hopelessly behind our powers of production in scientific background and direction. And without doubt we shall not achieve any marked relief from some of our industrial troubles until the same methods of analysis are applied to distribution, including tariff-making, that have produced our magnificent machinery of production.

Many economists believe that permanent technological unemployment is unlikely or even impossible. Briefly, they argue that, as has been stated, technological progress increases the quantity and reduces the cost of production. This in turn creates a greater demand and hence enlarges the opportunities for labor. Or, if the demand is inelastic, even at reduced costs, the savings, either to the consumer or the producer, are eventually invested through banks in the production of other products, and thus the field of industry is indirectly expanded. Unfortunately, we have little quantitative knowledge concerning these complex relations. There are some facts concerning some individual industries, however, that are illuminating.

The census of 1900 lists the number of workers in the shoemaking industry, both handicraft and factory, as 153,600 and gives their earnings as $63,304,344, or about $415 per person. This industry has been very fully mechanized, yet in 1914 the number employed was 191,555, with average earnings of about $522 per person. In 1925 there were 206,992 workers in the industry, with total earnings of $225,787,981, or about $1,090 per person. The purchasing power of the dollar of 1925 was about 66 per cent. of that of 1914 and 53 per cent. of that of 1900, but even with these allowances there has been a gain in real wages since 1900. Furthermore, in 1900 there were 4,849 children under 16 years of age employed in the industry, with yearly earnings of about $177 per year per child. No such conditions are tolerated to-day in progressive states.

Again, in the printing industry, which also has been highly mechanized, the census of 1900 gives the number of workers as 162,992 with yearly earnings of $84,249,963, or about $517 per person. The census of 1925 lists 251,276 persons as employed in this calling with total annual earnings of $438,832,974, or about $1,746 per person. Here again, allowing for the difference in the value of the dollar, there has been a decided gain in earnings. Furthermore, such statistics do not take into account the increased employment due to the production of machinery for these industries. In 1925 the value of the printing machinery produced in the United States was $69,216,683, and the corresponding value of shoemaking machinery was $11,769,137, and each of these machine industries in turn has many ramifications, the money value of which would be difficult to compute. No doubt an analysis of other industries over this period of rapid mechanization would show similar results and it would appear that so far as some individual callings are concerned, the recorded experience does not bear out in any way the gloomy predictions of the editor of the Census of 1900 quoted in a preceding paragraph. And it is fair to assume that under present circumstances any calling that is transformed by mechanization will stabilize "in the long run," as economists say, on a higher level so far as those workers who survive the change are concerned. We need not be troubled apparently at the *final* results of such metamorphoses. It is the *immediate* results of such changes that are now engaging the attention of thoughtful men.

It is usually assumed by ardent advocates of indus-

trial progress that the workers who are displaced by reason of advanced technological methods, whether mechanical or administrative, will find work elsewhere. This is not so easy to do. In former days, when industry was simpler, less specialized and less highly organized, such a transfer was not so difficult without great loss of time or economic standing: but conditions are vastly changed. The displaced worker is, in general, debarred from engaging in his wonted calling on his own responsibility, both for lack of funds and administrative experience. It is this lack, indeed, that makes cooperative production so difficult, if not impossible, under modern conditions. Again, the displaced worker can not, in general, engage in some other calling, at the same economic level, since his knowledge, skill and experience are not transmutable. If he does find employment in some other calling it is usually at a lower salary, that is, he suffers degradation of labor, so called. The few statistical studies that have been made of this problem indicate clearly that many displaced workers find employment elsewhere only after a considerable period of idleness and often at a lower wage scale. These difficulties are, of course, greatly increased where the decline in employment is such as to require the worker and perhaps his family to migrate to some distant point, a procedure that he faces with greatest reluctance. The most startling index of these new and changed conditions is the growing group of men over forty years of age that are finding it very difficult to get a foothold in industry once they are displaced for any cause. In this sense it may be that permanent technological unemployment already exists to a certain extent. It is, therefore, the immediate and not the ultimate results of technological progress that are of greatest concern and it is an open question as to how far we should permit the good of the majority to be advanced at the cost of suffering and poverty on the part of the minority. We are sadly lacking in accurate data as to the quantitative results of modern methods as affecting permanent unemployment. Perhaps nothing but a careful study of these phenomena or a pragmatic return to normal production can reveal to us with surety just what the true trends are, but in the meantime there are indications enough to put us on our guard as industry becomes increasingly scientific in its background and practices.

If an understanding of past progress and present conditions be important, some estimate of what the future may hold is even more so. The last thirty years has witnessed an unprecedented improvement in the science and art of production. Not only has this reshaped many of the old callings, but in some cases new and unheard-of industries based upon scientific processes have placed products on the market that have threatened or even obliterated old industries. In addition, the entire philosophy of industrial management has been rebuilt and made much more efficient. In its effect modern management is analogous to improved mechanical methods in that it aims to produce more per worker and hence tends to technological unemployment. There has also been a vastly greater use of power, particularly in heavy construction. Dean W. B. Donham, of the Harvard Graduate School of Business Administration, in his excellent and thought-provoking book, "Business Adrift," voices the opinion that "technological progress in the direction of better processes and methods will continue and accelerate during the generation ahead of us." He makes a similar prediction concerning the progress of efficient management. This may or may not be a true prediction, but if it be true, there are certain features of our economic life that must be studied carefully if our present system is to endure and if we are to keep up the present level of existence and escape extreme technological unemployment.

First, our home markets must be developed extensively. Foreign trade must, of course, be cultivated as heretofore, for the United States is far from being self-sufficient in the materials needed in modern industry, and it would appear that progressive nations are increasingly interdependent. But the field of foreign trade promises to be a very crowded place in the near future, and one in which our high tariff will not be a welcome passport. This means also the full evaluation of such economic theories as high wages and consequent high purchasing power. Our own people now purchase 90 per cent. of our products, it is said. Can this ratio be maintained if new methods greatly increase production? New inventions of economic value must be found, which, like the automobile, the radio, etc., will absorb the surplus labor and the increase in population. No such inventions are at present on the horizon, but no one knows what the day may bring forth. Industry individually and collectively must plan a program years in advance and thus endeavor to reduce the periods of feverish activity and corresponding periods of depression. Much thought is even now being given to this problem by forward-looking industrialists and economists in the hope that the business cycle can be controlled. Manufacturing must be freed from the incubus of speculation. Its inherent troubles are great enough without being thrown out of balance periodically by spasms in the stock market. It is inevitable, I believe, that we shall come to a shorter working week. There is nothing new or startling in this idea. Not many years ago the working day in most fac-

tories was twelve hours long for six days in the week, or 72 hours for the week. This working period has fallen steadily to approximately 44 hours a week of eight working hours a day. How much shorter the working week may be, time and technical developments alone will determine. And, lastly, management must provide a greater degree of security for the worker against unemployment and indigence in old age, the two calamities most dreaded by the worker. In such a program the effect of new technological processes in effecting unemployment must be studied in advance of their application. It may well be that we shall see legislation making it obligatory upon the part of ownership to provide some means of escape for displaced workers, though a happier solution would be a humanitarian interest in this problem on the part of the employing class that will minimize this difficulty by allowing longer period of readjustment and such provision for the transfer of displaced workers as may be possible. Unless some such program as this can be put into effect, an acceleration of our industrial machinery will make life unbearable for a large part of our population.

Personally, I am not convinced that the rate of progress during the next thirty years will be as rapid as during the last thirty. Scientific progress we shall surely see, and this is sure to be reflected in our industrial methods. But there are reasons, also, for believing that retarding factors are already at work. The most important of these is the old law of diminishing returns that so far has never failed to put in an appearance where economic progress has been active. Only a few of the more easily recognized indications of the working of this principle can be given here.

Consider first the transmission of intelligence by the telegraph and the telephone, which probably have accelerated the pace of modern industry as much as or more than any other factors. It is not conceivable that this quickening effect can be greatly increased. The solution of this problem is practically perfected. Since 1880 the time required to cross the continent by rail has been reduced from eight days to less than four. It is not conceivable that the next fifty years will witness anything like a proportionate reduction in rail time, and flying is still to be fully developed. Again in 1880 steamships were crossing the Atlantic in about eight days. The new giant liners now under construction are expected to make the passage in four days. Again it is not conceivable that this time will be reduced to two days in the next fifty years. The new methods of industrial management have accelerated industry and much more can be done in that field, but its limitations have already been evaluated by thoughtful observers. It is a well-known fact that in all engineering it is becoming progressively difficult to increase the efficiency of operation of power plants and machinery, in general.

Lastly, and most important of all, there are good reasons for believing that there are economic limitations to the growth in the size of manufacturing enterprises and consequently to the efficiency of mass production itself. Indeed, if the facts were known, it probably would be found that many modern industrial enterprises have already passed the point of greatest efficiency and greatest economic returns. The value of the industrial product per worker in this country in 1900 was about $1,600, while in 1919 (the last census in which such data are available) this ratio had risen to $7,500. Making due allowance for the changed value of the dollar, this is a great gain in production per worker. But *the ratio of the value of products to the capital invested has decreased* steadily for a number of years. In 1850 this ratio was close to 2, but it has fallen progressively until in 1919 it was only 1.39. This would appear to indicate that even if the number of workers were materially reduced in favor of more refined machinery the cost of production will eventually rise with increased complexity of mechanisms. This is already foreshadowed in some industries where the fully automatic machine as yet is not so economical as the semi-automatic operated by a skilled worker. Barring some new and eruptive change like the industrial revolution there is little likelihood of startling changes in the immediate future.

Finally, whether industrial progress be slow or rapid, these new methods are here to stay and their deeper significance should not be forgotten. Through them there is held out a hope that as we have achieved political and religious freedom, so we may also achieve economic freedom, freedom from physical drudgery and an opportunity for all men to live like men and not like beasts of the field, as the majority of our ancestors have done. But this will be no easy task, for it involves many changes in our ideas of economics and government. It involves the discarding of some economic ideas and taboos of Adam Smith and others who viewed industry as handicraft and the worker as a self-sufficient economic unit. And it also involves a realization on the part of ownership that it can no longer absolve itself from the responsibility of either controlling the business cycle or making the effort to provide continuous dividends to industry as it now does to insure continuous returns to capital. We can not continue with the present uncertain methods faced with even moderate technological progress.

Make no mistake in this matter. If we shall achieve a semblance of economic freedom for all men, a high

standard of life, security and delight in work, and leisure, it will be through much trouble and opposition, such as men have always encountered in winning political and religious freedom. There is an opportunity to attain this economic freedom in the United States by peaceful means, and this problem offers a challenge to business men, economists and engineers such as no similar group has ever had. Will they have the vision, courage and intelligent statesmanship to accept this challenge?

PREVENTION OF POLIOMYELITIS[1]

By Dr. SIMON FLEXNER

DIRECTOR OF THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH, NEW YORK

THE evidence presented on the mode of infection in poliomyelitis has established two important facts: First, that the disease is a particular form of infection of the upper respiratory tract; and second, that in harmony with other epidemic diseases of respiratory origin, the cases arising during an epidemic cover a wide latitude in degree of symptoms and pathological effects. There is consensus of opinion among clinicians that the number of children suffering some degree of infection, the slight cases expressing themselves as minor illnesses only, is very large, being in comparison with the number that are frankly paralyzed many times as great. The wide occurrence of the slighter forms of infection can be taken as a means, favorable in character, of delimiting the prevalence of the severer affection, since early experimental observations showed Lewis and myself[2] that any degree of actual infection, irrespective of whether muscular paralysis arose or not, protected the inoculated monkeys from the effects of a second administration of the virus.

Hence the investigation of the immunological phenomena in poliomyelitis became at once a rewarding field of experiment. The knowledge of the phenomena has become considerable during the twenty-year period of the experimental study of the disease, and the application of this knowledge to the prevention of epidemic poliomyelitis has met with encouraging results in the severe outbreaks occurring in New York State in 1931 and in Pennsylvania in 1932. I shall endeavor to guide you quickly through the main discoveries which have led to the practical achievements to be described. It is, however, necessary at the outset to explain that I have taken the lecturer's privilege of including in this statement certain later results bearing out the earlier ones presented, which were obviously not available when the lecture was delivered. It is sometimes advantageous to defer writing a lecture until the time of publication arrives, especially when, as in this instance, a new method has been under trial. During the intervening period, the method may have been given a wider test, with results sometimes favorable, and of course sometimes unfavorable to its employment. We appear in this instance to be in the happier situation, and while it is still too early to pass final judgment on available means of preventing poliomyelitis in the young during the prevalence of an epidemic, it is desirable that the nature of such means shall become widely known, since epidemic poliomyelitis continues to appear annually in some parts of America and Europe during the summer and autumn season.

The observation of Lewis and myself, already referred to, that monkeys which had recovered from an attack—irrespective of its severity—of experimentally induced poliomyelitis were not subject to reinfection, led quickly to the testing of the blood of recovered monkeys and human beings for immune substances to which the protection might be attributable.[3] Tests made almost simultaneously in France, Germany and the United States disclosed the existence in the blood, after recovery from the disease, of neutralizing, antiviral bodies. A mixture consisting of the virus of poliomyelitis and the serum of the blood was injected into monkeys. No symptoms of disease tended to arise from this injection; while mixtures of virus and normal monkey serum, or the serum of many, but not all persons not known to have had poliomyelitis, proved incapable of protecting the animals against the onset of the symptoms, including paralysis, characteristic of the experimental disease. I shall return a little later to a consideration of the circumstances under which the blood of supposedly normal individuals acts in a measure similar to that of persons known to have had paralytic poliomyelitis, since this action has come to have such pregnant meaning.

Let me repeat, the blood of normal monkeys invariably failed to act upon or neutralize the virus of

[1] Abstracted from the John M. Anders Lecture on Poliomyelitis delivered at the College of Physicians, Philadelphia, January 6, 1932.

[2] S. Flexner and P. A. Lewis, *Jour. Am. Med. Assn.*, liv, 45, 1910; *Jour. Exp. Med.*, xii, 227, 1910.

[3] P. H. Römer and K. Joseph, *Münch. med. Woch.*, lvii, 568, 1910; C. Levaditi and K. Landsteiner, *Compt. rend. Soc. biol.*, lxviii, 311, 1910; S. Flexner and P. A. Lewis, *Jour. Am. Med. Assn.*, liv, 1780, 1910; A. Netter and C. Levaditi, *Presse méd.*, xviii, 268, 1910.

poliomyelitis. The neutralizing property was detectable only when the inoculated monkeys had shown unmistakable signs of infection, although these signs may have been fleeting in character and wholly devoid of a paralyzing effect. Monkeys which receive the virus in the ordinary process of inoculation and resist all infection—either because the virus employed is too weak or too small a quantity is used, or because individual monkeys are exceptionally refractory—remain normal in regard to the antiviral action of the blood and capacity to respond with paralytic symptoms when a more effective inoculation is made.

In the light of the fact that monkeys are not naturally afflicted with poliomyelitis, as is man, it is significant to note not only that normal monkeys do not exhibit the blood antiviral property, but that the blood of recovered monkeys is weaker in antiviral substances than is the blood of recovered persons. For the sake of convenience it is customary to speak of the neutralizing, antiviral blood serum obtained from recovered persons and monkeys as "convalescent serum." Thus, monkey convalescent serum is less potent than human convalescent serum. But the potency of the former can be markedly increased by the additional injection of virus into recovered monkeys, a process which Lewis and I called reinforcement.[4] Reinforced (or hyperimmune) monkey serum equals or even surpasses in neutralizing power the convalescent serum obtained from human beings.

Neutralization of the virus by convalescent serum, monkey and human, was established originally by test tube experiments. As already stated, virus and serum were mixed before the mixture was injected into monkeys. Since under such conditions no infection occurred, the immediate question which arose was whether neutralization could also be effected inside the animal body, that is, when virus and convalescent serum were injected separately. While the test tube, or *in vitro* demonstration, of the presence of antiviral bodies in the blood undoubtedly threw light on immunity in poliomyelitis, it was thought that the determination of neutralization *in vivo* might possibly lead to therapeutic application. The tests carried out by Lewis and myself[5] consisted of the intracerebral inoculation of virus and the intraspinal injection of convalescent serum into monkeys. The intracerebral method is the most effective that is known for inducing the infection; the intrathecal injection is the most certain and efficient procedure for bringing the neutralizing serum into intimate relation with the nervous tissues, including the nerve cells, and hence for the blocking of the cells against the entrance of the virus, the injurious effects of which are responsible for the severe symptoms of the disease. While it is true that under physiological conditions the flow of the cerebrospinal fluid, into which the serum is introduced, is away from the nerve tissues, the small rise in pressure produced by the injection suffices to reverse the current, bringing the serum into intimate contact with all the constituents of the tissues, including the nerve cells.[6]

The results of the *in vivo* experiments can be stated briefly. When the virus is injected not longer than from 18 to 24 hours before the serum, and the amount of virus introduced into the brain does not exceed a fixed quantity, neutralization *in vivo* can be accomplished. Neutralization may be complete, when no symptoms whatever arise; or it may be partial, in which instance mild symptoms appear after a longer incubation period. Ordinarily the experimentally produced paralytic disease in the monkey is severer than the paralytic disease in man. While the mortality of the human affection is 20 per cent. or less, that of the frankly paralyzed monkey is 60 per cent. or more. When monkeys recover at all, they have as a rule merely passed through a mild attack of the experimental disease, such as is produced with weak virus strains or after partial neutralization of the virus. The *in vivo* experiments showed, therefore, that the action of the virus already present in the animal body could, under certain conditions, be suppressed. Suppression is, however, possible only when the immune serum is injected before symptoms of infection arise; once signs of infection are present, the serum is incapable of preventing the ordinary course of the disease from supervening.

The test by intracerebral inoculation is the most drastic one that can be devised. It exceeds in severity the conditions of infection occurring in man. In the human being, the virus is believed both to enter and to leave the nervous system by way of the nasal mucous membrane; we[7] early found that the virus implanted in the brain escapes into the nasal mucosa. This observation was quickly followed by the induction of the experimental paralytic disease through the instillation of the virus into the nares,[8] which finding in turn soon gave rise to the discovery that the intrathecal injection of serum prevents the development of infection by way of the nasal membrane.[9] It has,

[4] S. Flexner and P. A. Lewis, *Jour. Am. Med. Assn.*, liv, 1780, 1910; lv, 662.

[5] S. Flexner and P. A. Lewis, *Jour. Am. Med. Assn.*, liv, 1780, 1910.

[6] L. H. Weed and P. S. McKibben, *Am. Jour. Physiol.*, xlviii, 512, 1919.

[7] S. Flexner and P. A. Lewis, *Jour. Am. Med. Assn.*, liv, 535, 1910.

[8] S. Flexner and P. A. Lewis, *Jour. Am. Med. Assn.*, liv, 1140, 1910; S. Flexner, *Jour. Am. Med. Assn.*, lv, 1105, 1910.

[9] S. Flexner and P. A. Lewis, *Jour. Am. Med. Assn.*,

indeed, proven easier to prevent infection by the nasal than by the cerebral route of inoculation.[10] An important consideration is that the time interval between the nasal instillation of virus and the intrameningeal injection of serum may be lengthened with security beyond the period of safety that has been determined when the virus is inoculated into the brain. Moreover, convalescent serum injected into the meninges is equally capable of preventing infection by virus introduced into the blood;[11] and the immune serum is also protective, under certain circumstances, when the injection is made into the blood stream instead of into the membranes surrounding the brain and spinal cord.[12]

Professor Netter, of Paris, in 1911,[13] seized upon these experimental results and introduced into practice the convalescent serum treatment of poliomyelitis which has since been the subject of so much discussion. It soon became apparent that, once paralysis had appeared in human beings, the serum was quite powerless to influence the disease. As means of diagnosis became more accurate and instances of preparalytic poliomyelitis could be diagnosed with greater certainty, the use of the convalescent serum was increasingly restricted to these early cases. Medical opinion is still divided as to whether the serum is effective even under these circumstances. The matter has indeed become largely a statistical one, and hence it is not likely that a definite decision will be made immediately.[14] Epidemic poliomyelitis is a protean disease, symptomatically considered, and its effects are so varied that the outcome of individual preparalytic cases can not be predicted with certainty. Even the comparison of alternate cases in which serum is given with those from which it is withheld, is at best but a rough measure of effectiveness, since so much may depend on the way in which the choice of cases is made. I have attempted to formulate my own views on this debated subject[15] which I venture to restate here:

> My own experience has been chiefly with the experimental disease in monkeys. There the use of immune serum does make a difference. As between human beings and monkeys, the conditions are not identical; but the advantage is in part with human beings. Among them we find far more of the mild or preparalytic cases. In man there is, therefore, an inherently effective agency at work in aborting poliomyelitis. This agency is far less effective in monkeys in which the experimental disease tends to be severe and fatal. The severe form of the experimental disease in monkeys can be prevented or mitigated by means of immune serum. Since the practice of medicine is applied to individual cases of disease and does not, except statistically, deal with disease in mass, the question may fairly be asked whether the preexisting mechanisms in man tending to confine and abort the virus infection, can not in some instances be supplemented and fortified by convalescent serum. It is generally agreed that the use of the serum does no harm. Since it can not be affirmed that in individual cases it does no good, and a body of medical opinion exists in its favor, the question arises of whether its use should be withheld. This question is to be answered not by the pathologist, but by the physician. If a better, more calculable method of preventing paralysis were known, that is, a surer way of supplementing the normal mechanism tending to restrain the action of the virus before it causes functional injury to the nerve cells, this question would not arise. But there is no better or more calculable method known. The choice is, therefore, between no therapeutic intervention at all and a kind of intervention believed to be harmless and not known actually not to be sometimes useful in cases of this tragic disease.

Up to this point we have dealt with the restraint of the virus when it is mixed with immune serum in the test tube, or when the virus introduced into the animal body is followed by the injection of serum before symptoms of infection have arisen. The next problem to be considered related to the possibility of restraint of the virus when the serum is injected several days in advance of the virus. The answer to this question received from experimental work promises to bear on a possible preventive measure—passive serum protection—against epidemic poliomyelitis.

Stewart and I on addressing ourselves to the solution of this problem found that serum prevention is not only experimentally possible, but that the blocking effect against the entrance of the virus into the nerve cells endures for several days after an intraspinal injection, and occurs even after an intravenous injection of convalescent serum. Having in mind the practical implications of these observations, we proposed "that in the event of severe outbreaks of epidemic poliomyelitis, convalescent human serum be employed to afford passive protection to persons—children especially—menaced by the disease."[16]

The experimental results having been successful, we regarded it desirable to apply the method of protection to children and young adults exposed to epidemic

liv, 1780, 1910; S. Flexner, *Tr. Assn. Am. Physn.*, xxvi, 67, 1911.

[10] S. Flexner and H. L. Amoss, *Jour. Exp. Med.*, xxxi, 123, 1920.

[11] S. Flexner and H. L. Amoss, *Jour. Exp. Med.*, xxv, 525, 1917.

[12] S. Flexner and F. W. Stewart, *Jour. Am. Med. Assn.*, xci, 383, 1928; *New England Jour. Med.*, cxcix, 213, 1928.

[13] A. Netter, A. Gendron and Touraine, *Compt. rend. Soc. biol.*, lxx, 625, 1911.

[14] S. D. Kramer, W. L. Aycock, C. I. Solomon and C. L. Thenebe, *New England Jour. Med.*, ccvi, 432, 1932; W. H. Park, *Tr. Assn. Am. Physn.*, xlvii, 123, 1932.

[15] S. Flexner, *Jour. Am. Med. Assn.*, xcix, 70, 1932.

[16] S. Flexner and F. W. Stewart, *Jour. Am. Med. Assn.*, xci, 383, 1928; *New England Jour. Med.*, cxcix, 213, 1928.

poliomyelitis. During the next two or three years, of a number of such persons injected with convalescent serum, none developed the disease; but the number was too small to permit decisive conclusions. An opportunity came, however, with the overwhelming New York City epidemic of 1931, at which time we recommended the protective injection of convalescent serum or its near equivalent, blood from normal adults, parents by preference.[17] The amounts of convalescent serum available are too limited to serve for mass immunization. Several thousand children were treated in this manner, and among them the incidence of poliomyelitis was believed to be lower than in the uninjected population. The procedure employed was to withdraw from parents blood taken under sterile conditions and to inject 30 cubic centimeters or more of the uncoagulated blood intramuscularly into the children.

Allusion has been made to the fact that the blood of normal adults offers a substitute for the convalescent serum. The history of the discovery of the virus neutralizing property possessed by the blood serum of normal adults on the virus of poliomyelitis is instructive. In the year 1911, Anderson and Frost[18] investigated the so-called "abortive cases" of poliomyelitis to which Wickman's attention has been forcibly directed in the Swedish epidemic of 1905–1906.[19] The American investigators paid particular attention to the blood neutralizing reaction which had been described a short time before[20] by the employment of which they endeavored to establish the poliomyelitic nature of certain indefinite cases of illness which accompanied those of frank paralysis arising in the epidemic of poliomyelitis at Mason City, Iowa. In the course of their studies they made two observations, since confirmed, which are of special significance: first, that the blood of adults who had shown no signs of illness may possess considerable antiviral properties; and second, that the blood of young children, even when they have had an attack of the disease, may not develop promptly neutralizing power against poliomyelitis, or may develop it in a lesser degree than adults. Similar observations were made by Peabody, Draper and Dochez,[21] who studied the New York City epidemic of 1911. But it was Aycock and his associates[22] who studied the phenomenon more widely and concluded that a process of unperceived—subclinical—immunization of the adult population is taking place extensively to-day, thus explaining the antiviral activities now so generally found in the blood of normal persons. Aycock relates this subtle process to the similar one long known to be occurring in widely prevalent infectious diseases such as diphtheria and scarlet fever. Normal adult blood not only tends to contain the neutralizing substances in appreciable amounts, but in rare instances in quantities surpassing those present in the blood of persons who have recovered from undoubted attacks of poliomyelitis.[23]

However, it was not until the epidemic of 1932 in Philadelphia and other places in Pennsylvania that the method of passive immunization by the use of normal adult blood received not only wide, but more measured application. The analysis of these tests is being awaited with great interest. Certain favorable results have already been reported. But the completion of final results, and especially their interpretation, will require time and critical judgment. It is obvious, of course, that comparison should be made, where practicable, between large groups of children, injected and uninjected, both groups being similarly circumstanced as to age, environment and exposure. But it is also desirable to take into account the fact that certain adults are known not to possess the antiviral blood property; hence a standardized protective material can not be generally employed in the effort to produce passive immunization.

Finally, it must be remembered that tests on monkeys have disclosed two modes of intra-vitam action of the convalescent serum. In one, the virus is completely suppressed and no symptoms of infection arise; in the other, the action of the virus is mitigated, the incubation period before the appearance of symptoms being prolonged, and the symptoms themselves are milder. It is probable, therefore, that among the passively immunized children many will escape all signs of disease, and others—depending on all the circumstances stated—will fail to be protected, or will develop milder symptoms, taking into account the number receiving the adult blood in comparison with a corresponding number not so treated. We must await future events before attempting any general prediction on this important subject; but enough would appear to have been achieved already to warrant a further and wider trial of this safe and readily available means of preventing epidemic paliomyelitis which continues to be a serious menace on a world-wide scale.

One aspect of the subject of immunity in polio-

17 S. Flexner, SCIENCE, lxxiv, 251, 1931.

18 J. F. Anderson and W. H. Frost, *Jour. Am. Med. Assn.*, lvi, 663, 1911.

19 I. Wickman, Beiträge zur Kenntnis der Heine-Medinischen Krankheit (Poliomyelitis acuta und verwandter Erkrankungen), Berlin, S. Karger, 1907.

20 P. H. Römer and K. Joseph, etc., *loc. cit.*

21 F. W. Peabody, G. Draper and A. R. Dochez, Monographs of The Rockefeller Institute No. 4, 1912.

22 W. L. Aycock and S. D. Kramer, *Jour. Prevent. Med.*, iv, 189, 1930.

23 H. J. Shaughnessy, P. H. Harmon and F. B. Gordon, *Jour. Prevent. Med.*, iv, 463, 1930; M. Brodie, *Jour. Exp. Med.*, lvi, 507, 1932.

myelitis remains to be considered. We have long known that monkeys may be rendered actively immune by successive small injections, or one large injection, of poliomyelitis virus made beneath the skin[24] or by successive inoculations made into the skin.[25] Both these methods of securing immunity suffer from the disadvantage that occasionally monkeys develop paralysis instead of immunity. It appears that monkeys, in common with human beings, exhibit varying degrees of susceptibility to the presence of the virus in the body. An effort is being made to improve and perfect this means of active immunization in order to avoid the rare onset of disease. The combined use of immune serum and virus offers greater security. That active immunity can be obtained by the injection of mixtures of the serum and virus has been shown by Rhoads.[26] Recently we have carried out experiments on a larger scale, in which virus and serum have been injected separately into the body of monkeys. These animals developed active immunity and, up to the present, without the appearance of symptoms of infection in any case. Moreover, evidence is accumulating that as the original, human virus is passed from monkey to monkey, it undergoes modification, and while retaining its immunizing properties, changes its infective power. Whether or not use may be made of this transformation in securing active immunization of human beings when menaced by epidemic poliomyelitis, future study alone can determine.[27]

[24] S. Flexner and P. A. Lewis, *Jour. Am. Med. Assn.*, lv, 662, 1910; C. P. Rhoads, *Jour. Exp. Med.*, li, 1, 1930.

[25] W. L. Aycock and J. R. Kagan, *Jour. Immunol.*, xiv, 85, 1927; F. W. Stewart and C. P. Rhoads, *Jour. Exp. Med.*, xlix, 959, 1929.

[26] C. P. Rhoads, *Jour. Exp. Med.*, liii, 115, 1931.

[27] S. Flexner, *Jour. Am. Med. Assn.*, xcix, 1244, 1932.

OBITUARY

RUFUS LOT GREEN

PROFESSOR RUFUS LOT GREEN, professor emeritus of mathematics at Stanford University, died in Palo Alto, California, on November 19 at the age of 71. With the death of Professor Green, Stanford University loses one of its most faithful servants, teachers, counselors and friends, and the community one of its most serviceable citizens.

It does not fall to the lot of every man in academic work to stand out as a teacher par excellence, a counselor with wise judgment, a citizen with a high sense of public duty and a friend with understanding mind and heart. So did this man, best known, however, only to his colleagues, students and friends. The name of Professor Green does not stand out in the annals of science, nor will historians of science record any great achievements of his in mathematical research or published monographs—but in the hearts of his students are indelibly impressed the sterling and modest qualities of a quiet and unassuming teacher, endowed with high ideals of true scholarship. For a period of over 40 years, teaching mathematics was his one great task.

Professor Green was born in Rush County, Indiana, on March 3, 1862, the son of Samuel and Elizabeth Anne (McKee) Green. He showed early aptitude for both mathematics and natural history. His first two years in college were spent at the University of Indiana from 1879 to 1881 under Daniel Kirkwood in mathematics and David Starr Jordan in natural history. From 1881 to 1883 he attended Cornell University, after which he returned to Indiana University, where he graduated in 1885 with a B.S. degree, and immediately became an instructor in mathematics at his alma mater. During this time he prepared for his master's degree, which he received in 1888. His long teaching career was interrupted only once when he spent one year as a graduate student and fellow by courtesy at Johns Hopkins University in 1887–88 under Sylvester. Professor Green's advancement was rapid; he filled successfully the position of associate professor (1886–90) and attained the position of full professor at the age of 28 (1890–93) during the period of David Starr Jordan's presidency of Indiana University (1885–91). Two years after the new university Leland Stanford first opened its doors in 1891 with Dr. Jordan as president, Professor Green received a call to become associate professor of mathematics, and in 1894 he was promoted to full professorship. He was just a year too late to be classified with the "Old Guards," an affectionate term for the pioneer professors who came with Dr. Jordan. (It was three years later that the writer became a student of his and formed a friendship which endured until Professor Green's death.) He became executive head of the department of mathematics in 1925, from which position he retired in 1927.

In the councils of affairs of the university he assumed more than his full responsibility on various committees. He was best known, however, as chairman of the students' affairs committee. His fairness and justice in administering student disciplinary cases won him great respect and esteem. The students recognized in Professor Green a man of high principles and this made him a favorite among them.

The work in his classroom was unusually interesting

in that he presented the subject-matter with a feeling of freshness and clarity. For mathematics was to Professor Green a live and growing science; he constantly emphasized the theoretical and practical phases, showing their parallel with the philosophical aspect. One of his favorite and constant admonitions to students on giving an examination was that the purpose of a test was to see what we could do "under pressure." He introduced a number of new courses to Stanford, one of which particularly interested him, namely, statistical mathematics.

His broad and catholic interest in life and its problems manifested itself in his interest in economic, social and political problems. So well was he posted on various issues that during political periods he was constantly sought by his colleagues and by organizations for advice and elucidation of the problems. His was the habit of clear thinking. Although he was never robust in health, he loved outdoor life and during his early days at Stanford, like David Starr Jordan, he was a leader in mountain walking with his students. For many years during the summer period he directed a camp in the Yosemite Valley, later becoming director of the Yosemite Park and Curry Company.

Professor Green was a fellow of the American Association for the Advancement of Science, member of the American Mathematical Society, Mathematical Association of America, American Economic League, Academy of Political and Social Science, American Political Science Association, California Academy of Science, American Museum of Natural History, and American Association of University Professors.

Thus closed an active and full life, devoted to state, church and university.

On August 11, 1886, he had married Miss Emma Edwards, of Knightstown, Indiana, who in addition to two daughters and one son survives him.

FREDERICK E. BRASCH

EVERHART PERCY HARDING

ON October 10, 1932, Professor Harding died at his home in Minneapolis after an illness of more than two years. Before his retirement, owing to ill health, in September, 1931, he was the only remaining member of the staff of chemistry of the University of Minnesota whose service antedated the foundation in 1904 of the school of chemistry as an independent faculty. His connection with the university as a student and as a staff member extended over more than forty years.

Professor Harding was born on August 15, 1870, at Waseca, Minnesota, where he had his early education. He entered the University of Minnesota in 1890 and maintained a high record of scholarship during his entire career, achieving election to Phi Beta Kappa and later to Sigma Xi. At the same time, he set an all-time record for athletic prowess, especially in football. Participation in intercollegiate athletics was at that time not limited to three years, so that his career as an athlete was continued through the entire period of his undergraduate and graduate years. He took the bachelor's degree in 1894 and was awarded a scholarship, which enabled him to take the M.S. degree in 1895.

After serving as instructor in chemistry from 1896 to 1899, he pursued further studies in chemistry under Professor Curtius at the University of Heidelberg, where he was granted the Ph.D. degree in 1901. From 1905 until his retirement, he was successively assistant professor and associate professor of chemistry. He also took a prominent and responsible part in the management and supervision of intercollegiate athletics.

During the decade prior to his death, Professor Harding was in charge of technological chemistry, a division of the school of chemistry which comprised instruction and research in chemical technology, particularly of foods and fuels. It was in these fields that most of his researches were made, although some of his earlier work was devoted to pure organic chemistry. His interest in fuels led him to investigate extensively the presence and distribution of sulfur in oil shales for the determination of which he developed methods of unusual accuracy.

Professor Harding was frequently called on for public service and acted as consultant for industries of the state, particularly in connection with city gas supplies. Early in his career, he rendered valuable aid in the introduction of the sugar beet industry into Minnesota.

In all his relations, Professor Harding was characterized by his spirit of loyalty and by the strictest conscientiousness in the performance of all duties. He was equally devoted to his students and to research, which he carried on until his health failed. He was a member of Phi Beta Kappa, Sigma Xi, Phi Lambda Upsilon honor societies, of Alpha Chi Sigma and Phi Delta Theta fraternities and of numerous professional and scientific societies.

He is survived by his widow and three children.

S. C. LIND

RECENT DEATHS

DR. ELIAKIM HASTINGS MOORE, professor emeritus of mathematics at the University of Chicago, died on December 30. He was seventy years old.

DR. JOHN J. CARTY, vice-president and chief engi-

neer of the American Telephone and Telegraph Company, retired, died on December 27 at the age of seventy-one years.

Dr. Edwin Chapin Starks, who recently retired as associate professor of zoology at Stanford University, died on December 30 at the age of sixty-five years.

Dr. Theodor Holm, known for his work on Arctic botany and on plant anatomy, died in Washington, D. C., on December 26 at the age of seventy-eight years.

Dr. George Fetterolf, professor of otolaryngology at the University of Pennsylvania, died on December 29 at the age of sixty-three years.

Leon R. Streeter, chief in research, in charge of the chemical work on fungicides and insecticides of the division of chemistry, New York State Agricultural Experiment Station, died on December 26, aged thirty-eight years.

Dr. William A. LaField, professor of radiology at Yale University, committed suicide on December 26. He was fifty-two years old.

Dr. Ernest Howe, consulting mining geologist, an editor of the *American Journal of Science*, died on December 18. Dr. Howe was fifty-seven years old.

Frank W. Skinner, consulting engineer of New York City, died on December 26 at the age of seventy-four years.

Dr. Allan Douglas Risteen, director of technical research and editor of safety publications for the Travelers Insurance Company of Hartford, Connecticut, died on December 30 at the age os sixty-six years.

John H. Stevens, chemical expert for the Celluloid Corporation of Newark, New Jersey, died on December 4. He was seventy-nine years old.

W. H. Fry, of the Division of Soils of the U. S. Department of Agriculture, died suddenly at the age of forty-four years on December 28.

Simon William Dykshorn, assistant at the experimental laboratories of the Carnegie Institution of Washington at Cold Spring Harbor, while hunting for scientific purposes, shot himself fatally on December 25. He was twenty-seven years old.

Dr. Georges Haret, head of the radiology department at Lariboisière Hospital, Paris, died on December 20, as a result of x-ray burns incurred in the course of his work. He was fifty-eight years old.

MEMORIALS

The centenary of the birth of Julius von Sachs, the German botanist who founded plant physiology as a modern experimental science, was celebrated during the Atlantic City meeting of the American Association for the Advancement of Science. The memorial program on December 28 was led by Professor D. H. Campbell, of Stanford University, representing the Botanical Society of America; Professor Rodney H. True, of the University of Pennsylvania, representing the American Society of Plant Physiologists, and Professor C. E. Allen, of the University of Wisconsin, representing the botanical section of the American Association for the Advancement of Science.

The Johns Hopkins University Institute of the History of Medicine commemorated on December 20 the three hundredth anniversary of the birth of Antony Van Leeuwenhoek, 1632–1723. Dr. William H. Welch, formerly director of the institute, gave an illustrated lecture on Van Leeuwenhoek and his work. A film, made especially in Holland to commemorate the tercentenary, was shown. There was also an exhibit of illustrative books, documents and instruments.

To commemorate the bicentenary of the birth of Sir Richard Arkwright, inventor of the yarn spinning frame, the Newcomen Society arranged a public lecture which was delivered on December 14 by Mr. Frank Nasmith.

The University of Manchester has received from Mrs. R. W. Williamson a portrait in oils of her father-in-law, the late Professor W. C. Williamson, who was in charge of the teaching of zoology, botany and geology in Owens College from 1851 until 1892.

SCIENTIFIC EVENTS

THE YEAR AT THE FIELD MUSEUM OF NATURAL HISTORY

Despite enforced economies, due to reduction of its income from endowment and other sources because of the depression, Stephen C. Simms, director of the Field Museum of Natural History, reports that the museum maintained full service to the public during 1932, and its educational benefits were extended to a greater number of persons than in any previous year of its history.

While extra-mural activities such as scientific expeditions were curtailed, the museum carried on a full program of installing new exhibits and making general improvements, presenting free courses of illustrated lectures on science and travel for the general public, maintaining manifold educational activities for school children both at the museum and by extension work in the schools of Chicago, and issuing scientific publications.

A total of more than 1,800,000 persons have visited

the museum during the year. This is the largest attendance of any year, and represents an increase of nearly 300,000 or about 20 per cent. over the 1931 total of 1,515,540 visitors. The year 1932 was the sixth in which attendance has exceeded 1,000,000; and the total for the past five years has been more than 6,840,000, or approximately 1,000,000 more than the 5,839,579 visitors received in the entire twenty-five years during which the museum has occupied its first building in Jackson Park.

The outstanding new exhibit completed during the year is a reproduction of an African water-hole, a group with twenty-three mounted mammals, including giraffes, rhinoceroses, elands, gazelles, zebras and an oryx. This is the largest exhibit in the museum, and is one of the largest animal groups in any museum, possibly exceeding all others in size. Other groups of animals with reproductions of their natural habitats which were completed during 1932 include Alaskan caribou, Asiatic water buffalo, and the mountain lion of states west of the Rockies. In addition to such groups, many other new zoological exhibits were installed, while each of the other departments—anthropology, botany and geology—made notable additions and improvements among their exhibits, especially in the divisions of Chinese archeology, paleontology or historical geology, and in the Hall of Plant Life.

More than 265,000 persons attended the lecture courses and lecture tours provided by the museum for adults, and the series of motion picture programs, extension lectures, and other activities for school children given by the James Nelson and Anna Louise Raymond Foundation for Public School and Children's Lectures (the foundation is a unit of the museum organization with special endowment). Likewise, the more than 1,300 traveling exhibits of the N. W. Harris Public School Extension Department, another specially endowed unit, were circulated continually throughout the school year among public and private schools of Chicago with a total enrolment of about 500,000 children. A large public was served also by the library of the museum and the study collections of specimens maintained in each department.

ADVANCED STUDIES IN ENGINEERING AND BUSINESS FOR DISENGAGED ENGINEERS

LEADERS in industry, engineering and education are sponsoring "Advanced Studies in Engineering and Business for Disengaged Engineers" to be given during the winter and spring under the auspices of the Engineering Foundation, according to an announcement made by H. Hobart Porter, chairman of the foundation. The courses will be conducted by unemployed or volunteer teachers under the supervision of members of the faculties of Columbia University, New York University, Stevens Institute of Technology and the Polytechnic Institute of Brooklyn. The business courses will be directed by members of the faculty of the School of Commerce of New York University.

The curriculum embraces six courses. Sessions are to be held in the forenoon beginning on January 9 and will continue for twenty weeks to the end of May. The opportunity is open to unemployed engineers who have the requisite education for pursuing the work.

These are free and deal with business finance, sales engineering, power plant engineering, structures and mechanical equipment of buildings, industrial applications of electricity and industrial management. Rooms for class use will be made available in the Engineering Societies Building and the Engineering Societies Library will place text and reference books at the disposal of class members. Requests for application blanks should be addressed to P. H. Littlefield, manager, in care of the Engineering Foundation, 29 West 39th Street, New York City. The movement is sponsored by the following:

Robert P. Lamont, president, American Iron and Steel Institute; A. G. Pratt, president, Babcock and Wilcox Company; Robert Ridgway, consulting engineer, Board of Transportation of New York City; Alfred P. Sloan, president, General Motors Corporation; Morse A. Cartwright, director, Association for Adult Education; Dean J. W. Barker, Engineering School, Columbia University; Dean Collins P. Bliss, Engineering School, New York University; Dean John T. Madden, School of Commerce, New York University; Dr. Harvey N. Davis, president of Stevens Institute of Technology, Hoboken, New Jersey; Dean E. J. Streubel, Polytechnic Institute of Brooklyn; H. A. Kidder, president, United Engineering Trustees, Inc.; H. Hobart Porter, chairman, Engineering Foundation; Admiral F. R. Harris, general chairman, Professional Engineers' Committee on Unemployment; George T. Seabury, secretary, American Society of Civil Engineers; A. B. Parsons, secretary, American Institute of Mining and Metallurgical Engineers; Calvin W. Rice, secretary, American Society of Mechanical Engineers, and H. H. Henline, acting national secretary, American Institute of Electrical Engineers.

AWARD OF THE PERKIN MEDAL TO MR. OENSLAGER

GEORGE OENSLAGER, of Akron, Ohio, whose researches are said to have revolutionized the rubber industry, will be presented with the 1933 Perkin Medal of the Society of Chemical Industry at a national gathering of the chemical societies on the evening of January 6 at the Electrical Institute Auditorium, Grand Central Palace, New York City.

The award goes to Mr. Oenslager as "the American scientist who has most distinguished himself by his

services in applied chemistry." Other organizations participating are the American Chemical Society, the American Electrochemical Society, the American Institute of Chemical Engineers and the American Section of the Société de Chimie industrielle.

Alfred P. Jones, of the Houston Properties Corporation, will detail the accomplishments of Mr. Oenslager which led to the award. Professor Marston T. Bogert, of Columbia University, past president of the American Chemical Society and of the Society of Chemical Industry, will make the presentation. Mr. Oenslager will deliver an address describing the development of organic accelerators for rubber vulcanization. Dr. A. E. Marshall, of New York, chairman of the award committee, will preside.

"Five major achievements mark the change in rubber technology during the past thirty years," according to the announcement of the award committee. "These are reclaimed rubber, the cord tire, the carbon black tread, the nitrogenous organic accelerator and antioxidants. Mr. Oenslager may be credited with two of these—the carbon black tread and the nitrogenous organic accelerator. As a direct result of his efforts the rubber industry has been revolutionized and from it have come economies of manufacture, increase in service and savings to consumers which run into the hundreds of millions of dollars annually."

Mr. Oenslager began his researches in 1906, setting out with the definite object of finding substances to be used in rubber mixtures which would decrease the rate of cure and increase the physical qualities of low grades of crude rubber. He found that the best organic accelerators contained nitrogen and his discovery has been put to wide use.

His experiments also laid the foundation for the most widely accepted theory of vulcanization—that zinc oxide is necessary to vulcanization with most of the nitrogen accelerators. He also viewed rubber as a colloid which needed uniformity of dispersion and toward this end he introduced what is known as the master batch.

In 1911, Mr. Oenslager developed the carbon black tread for automobile tires which was adopted for large scale production the following year.

"Were we to remove these two main features from tires to-day," the award committee points out, "the mileage figures would drop to one half the present values. If the modern tire can show savings to consumers over those of twenty-five years ago of $800,000,000 a year, then appraise the accelerator and the carbon black at a $400,000,000 annual saving and it will not be far out of line."

Mr. Oenslager was born in Harrisburg, Pennsylvania, in 1873. After attending schools in that city he prepared for college at Phillips Exeter Academy, entering Harvard University in 1890. While in college he became greatly interested in chemistry and after his graduation in 1894 he devoted two years of study to that science in the Harvard Graduate School.

In 1896 he became associated with S. D. Warren and Company as a chemist and remained in that post for nine years. In 1905 he was appointed research chemist to the Diamond Rubber Company. This company later was purchased by the B. F. Goodrich Company, with which Mr. Oenslager is now associated.

OFFICERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

A FULL account of the Atlantic City meeting of the American Association for the Advancement of Science, and the scientific societies associated with it, edited by the general secretary, Dr. Burton E. Livingston, will be published in the issue of SCIENCE for February 3. Officers of the association were elected on December 30 as follows:

PRESIDENT

Henry Norris Russell, Princeton University.

PERMANENT SECRETARY

Henry B. Ward, University of Illinois.

GENERAL SECRETARY

Burton E. Livingston, the Johns Hopkins University.

TREASURER

John L. Wirt, Carnegie Institution of Washington.

MEMBERS OF THE COUNCIL

George T. Hargitt, Duke University.

Dugald C. Jackson, Massachusetts Institute of Technology.

MEMBERS OF THE EXECUTIVE COMMITTEE OF THE COUNCIL

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SCIENTIFIC NOTES AND NEWS

AT the banquet of the Cambridge meeting of the Geological Society of America the fifth presentation of the Penrose Medal for distinguished achievement was made to Dr. Edward Oscar Ulrich, of Washington, who recently retired after long service with the U. S. Geological Survey. The presentation was made by Dr. W. O. Hotchkiss, president of the Michigan College of Mines. At the same time the society honored the sole survivor of the thirteen men who formed it in 1888, Dr. Herman LeRoy Fairchild, professor emeritus of geology at the University of Rochester, with the presentation of an inscribed copy of "The Geological Society of America," a history which he helped to prepare. Dr. Fairchild is a former president of the society.

AT the close of the recent meeting at Washington of the National Council of Geography Teachers, the first award of the certificate of merit for service in teaching geography was presented to Dr. William Morris Davis, professor emeritus of geology at Harvard University.

DR. HENRY EYRING, research associate in chemistry at the Frick Chemical Laboratory of Princeton University, received the ninth annual $1,000 award of the American Association for the Advancement of Science at the close of the Atlantic City meeting. The prize was given for Dr. Eyring's paper entitled "Quantum Mechanics of Conjugate Double Bonds," presented to the chemical section.

THE annual gold medal award for conspicuous achievement in the medical sciences, given by the Phi Lambda Kappa fraternity, was presented to Dr. Béla Schick, of the Mount Sinai Hospital, New York City, discoverer of the Schick test for diphtheria, at the annual dinner on January 1. The annual gold medal award for the best thesis on a medical subject written by an undergraduate medical student was presented to Myron G. and Maurice M. Rosenbaum, of the University of Buffalo School of Medicine.

THE Rudolf-Virchow Medal of the Berlin Anthropological Society has been awarded to Professor Karl Pearson, director of the Francis Galton Laboratory for National Eugenics, University of London.

Nature reports that in commemoration of the seventieth birthday of Sir P. C. Rây, founder, foundation-president and patron of the Indian Chemical Society, a jubilee volume of some 350 pages is being published by the society, containing contributions from many eminent chemists in India and abroad.

DR. MARCHOUX, professor at the Institut Pasteur, Paris, has been nominated a Grand Officer of the Legion of Honor.

DR. CHARLES ZELENY, professor of zoology at the University of Illinois, was elected president of the American Society of Zoologists at the Atlantic City meeting.

AT the Cambridge meeting of the Geological Society of America the following officers were elected: Dr. Charles Kenneth Leith, of the University of Wisconsin, *president;* Professor Rollin T. Chamberlin, University of Chicago; Dr. E. M. Kindle, chief of the Division of Paleontology of the Canadian Geological Survey; Professor E. S. Moore, of the University of

Toronto, and Herbert P. Whitlock, curator of mineralogy at the American Museum of Natural History of New York, *vice-presidents.* Dr. Charles P. Berkey, of Columbia University, continues as secretary for his eleventh term, and Professor Edward B. Mathews, of the Johns Hopkins University, continues as treasurer.

THE Paleontological Society of America elected E. M. Kindle, of Ottawa, *president;* E. B. Branson, University of Missouri, *first vice-president;* J. B. Reeside, Washington, D. C., of the United States Geological Survey, *second vice-president;* M. A. Hanna, Houston, Texas, *third vice-president;* B. F. Howell, Princeton University, *secretary;* C. O. Dunbar, of Yale University, *treasurer,* and Walter Granger, of the American Museum of Natural History, New York City, editor of the *Bulletin.*

OFFICERS elected by the Mineralogical Society of America were Herbert P. Whitlock, curator of mineralogy for the Morgan-Tiffany collection at the American Museum of Natural History, New York City, *president;* Frank R. Van Horn, Case School of Applied Science, Cleveland, Ohio, *secretary,* and Waldemar T. Schaller, of the U. S. Geological Survey, *treasurer.*

As has already been announced, the annual meeting of the British Association will be held next year in Leicester from September 6 to 13, under the presidency of Sir F. Gowland Hopkins, of the University of Cambridge, president of the Royal Society. *Nature* reports that the following sectional presidents have been appointed: Section A—Mathematical and Physical Sciences, Sir Gilbert Walker; B—Chemistry, Professor R. Robinson; C—Geology, Professor W. G. Fearnsides; D—Zoology, Dr. J. Gray; E—Geography, the Right Hon. Lord Meston; F—Economic Science and Statistics, Professor J. H. Jones; G—Engineering, R. W. Allen; H—Anthropology, the Right Hon. Lord Raglan; I—Physiology, Professor E. D. Adrian; J—Psychology, Professor F. Aveling; K—Botany, Professor F. E. Lloyd; L—Educational Science, J. L. Holland; M—Agriculture, Dr. A. Lauder.

THE Royal College of Physicians and Surgeons of Canada has conferred honorary fellowships on Lord Bessborough, and on Dr. John Stewart and Dr. I. H. Cameron, emeritus professors of surgery at Dalhousie and Toronto Universities, respectively.

THE title of emeritus professor has been conferred on Dr. William Savage Boulton, who recently retired from the chair of geology at the University of Birmingham.

PROFESSOR W. M. GARDINER, principal of the Technical College, Bradford, will relinquish the editorship of the *Journal* of the Society of Dyers and Colorists at the end of the present year, after holding it for thirty-four years. Dr. F. M. Rowe, professor of color chemistry at the University of Leeds and foreign editor of the journal, has been appointed in his place as co-editor with Mr. Ellis Clayton, chief lecturer in dyeing and cellulose chemistry at the Technical College, Bradford.

DR. DOUGLAS H. SPRUNT, New York, was recently appointed assistant professor of pathology at Duke University School of Medicine, and Dr. Ernest M. Poate, Southern Pines, professor of psychiatry.

HAROLD P. FAWCETT, instructor in mathematics, Columbia University, has become assistant professor of mathematics in the Ohio State University.

DR. LUDWIG HEKTOEN, professor of pathology at the University of Chicago and director of the John McCormick Institute for Infectious Diseases, has been elected chairman of the Board of Governors of the Chicago Institute of Medicine.

DR. GILBERT E. DOAN, associate professor of metallurgy at Lehigh University, has been granted for 1933 a sum of money sufficient to employ a research fellow in continuation of studies of pure iron for arc welding. The study is foundational to the investigation of quality of steel for arc welding, and is sponsored by the Engineering Foundation.

THE *Journal* of the Washington Academy of Sciences reports that Frank T. Davies, formerly of the Byrd Antarctic Expedition, and now on furlough at the request of the Meteorological Service of Canada, from the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, is in charge of the Polar Year station at Chesterfield Inlet. This station is the nearest point to the North Magnetic Pole at which continuous records will be taken during the Polar Year. W. J. Rooney, of the Department of Terrestrial Magnetism, who was temporarily assigned to the U S. Coast and Geodetic Polar Year Station at College, Alaska, to assist in the installation of the atmospheric-electric and earth-current equipment, has completed his work and returned to Washington. K. L. Sherman will be in charge of the work during the Polar Year.

PROFESSOR H. WEYL, of the University of Göttingen, has accepted the invitation of Swarthmore College to give the William J. Cooper Foundation Lectures for 1932–33. He will reside at Swarthmore from the middle of February until the middle of March. During this period he will give five lectures on the gen-

eral subject of "Mind and Nature" and will take part in the honors work of the college.

DR. J. C. DRUMMOND, professor of biochemistry, University College, London, will deliver the next Lane Lectures early in April at the Stanford University School of Medicine in San Francisco. Professor Drummond expects to arrive in San Francisco about April 1, 1933. There will be five lectures, under the general title of "Recent Advances in the Biochemical Study of Nutritional Disorders." The lectures are to be published later.

DR. HENRY A. CHRISTIAN, Hersey professor of the theory and practice of physic at Harvard University Medical School, Boston, conducted the third graduate teaching clinic at the Central Maine General Hospital, Lewiston, from November 21 to 22. Dr. Christian gave an address on "Cardiac Disease and Its Treatment."

DR. WALTER B. CANNON, George Higginson professor of physiology at the Harvard Medical School, will give the Beaumont Lectures of the Wayne County Medical Society, on January 30 and 31. The subject tentatively selected is "The Relation of the Autonomic System to the Functions of the Alimentary Canal."

A SERIES of scientific discussions will be offered by the Institute of Arts and Sciences of Columbia University during the next three months. Michael Pupin will discuss the "Future of Science"; Dr. Arthur H. Compton, of the University of Chicago, will speak on "Cosmic Rays and their Significance"; Dr. John Bellamy Taylor, of the General Electric research staff, will speak on "Audible Light"; Albert Edward Wiggam, author of "The New Decalogue of Science," will lecture on "Biology in Human Affairs"; Professor Walter Rautenstrauch, of Columbia University, will analyze technocracy, and Auguste Piccard, of Belgium, will tell of his explorations of the stratosphere.

ON behalf of the Geological Society of America, its president, Professor Reginald A. Daly, of Harvard University, has protested the proposed cuts in Congressional appropriations for the U. S. Geological Survey. In a statement to Science Service, Professor Daly said: "Directly and indirectly geological service is a principal aid to American business in locating underground raw materials. If the U. S. Geological Survey is now seriously crippled it will be costly if not impossible to restore personnel and skilled experience. Applied geology and profitable mining depends on research of the survey type and to destroy any of the survey's efficiency would be bad economy from the viewpoint of the American consumer of goods that are made from metallic and non-metallic underground raw materials. The Geological Society of America would regard a serious cut of the survey's budget a major disaster for the producers of wealth in this country."

SUPPORT of President Hoover's executive order transferring river and harbor engineering work now directed by army engineers to a new Division of Public Works in the Interior Department is announced by the American Engineering Council, representing 60,000 engineers in this country. The reorganization will remedy the present War Department control that is "exceedingly undemocratic and unfair to the more than 200,000 professional engineers of the United States and particularly so to that faithful and efficient group of civilian engineers" working under the War Department. The council predicted material savings in cost, elimination of waste and increase of efficiency when the reorganization is effective.

A BEQUEST of $150,000 for a professorship of geography at Princeton University and one of $500,000 to the Geographical Society of Philadelphia, are included in the will of Henry Grier Bryant, noted explorer, who died on December 7. The American Philosophical Society will receive $10,000 for its building fund, and $5,000 each is to go to the Museum of the University of Pennsylvania, the Pennsylvania Academy of the Fine Arts, the Children's Country Week Association and the Appalachian Mountain Club of Boston, the interest to be applied "to the maintenance of refuge huts or mountain trails operated by the club."

THE twenty-third annual exhibition of scientific instruments and apparatus, arranged by the Physical Society, London, was held from January 3 to 5 at the Imperial College of Science and Technology, South Kensington. If the program given in *Nature* was carried out the leading manufacturers of scientific instruments exhibited their latest products in the Trade Section. The Research and Experimental Section contained contributions from most of the important research laboratories in Great Britain, and there was a special sub-section devoted to experiments of educational interest. In addition, the work submitted for the craftsmanship competition by apprentices and learners was on view. Discourses were delivered each day at 8 P. M. as follows: January 3, Dr. Allan Ferguson: "Surface Tension and its Measurement"; January 4, Mr. R. A. Watson Watt: "Cathode Ray Oscillography"; January 5, Mr. F. Hope-Jones: "Time Measurement: Old and New."

THE Morris Foundation that has recently affiliated the Morris Arboretum at Chestnut Hill, Philadelphia, with the University of Pennsylvania, has also provided funds for a number of graduate fellowships for students in botany working for higher degrees. A sti-

pend of $1,250 accompanies each appointment. Since appointments may take effect with the middle of February, applications for consideration should be sent at an early date to the Director of the Morris Arboretum, at the Department of Botany, University of Pennsylvania.

DISCUSSION

THE USE OF VITAMIN D FROM COD-LIVER OIL IN MILK AND BREAD

As was pointed out in an editorial which appeared in the *Journal* of the American Medical Association for November 26, 1932, it would be of advantage if antirachitic properties could be imparted in a suitable degree to a few foods (such as milk and bread) that enjoy wide-spread use, particularly in the dietary of childhood, because, in spite of several years of vigorous antirachitic propaganda, rickets remains all too prevalent in many communities.

Work with this specific objective in view has been carried on for some years at Columbia University. During the course of experiments conducted for the purpose of determining what substance in cod-liver oil conferred on this oil its well-known therapeutic value in the treatment of rickets, it was found that the antirachitic factor (to which McCollum gave the name of "vitamin D") could be concentrated in a fraction representing a very small part of the original oil.

The process by which this concentration is effected is briefly as follows: The cod-liver oil is treated with 95 per cent. ethyl alcohol, which dissolves out the antirachtic substance together with some other materials, chiefly fatty acids. The fatty acids are saponified, precipitated as calcium soaps, and treated with acetone which removes the active substance. The acetone solution is concentrated, and then treated with ether. After further purification of the ether solution, the ether is distilled off, leaving a brownish, waxy residue (still a very complex mixture) which can be conveniently handled dissolved in oil.

Rat assays showed this concentrate to be highly antirachitic, and later tests at the Children's Clinic of Bellevue Hospital and other health centers showed that it possessed the same curative effects on rachitic infants known to be produced by cod-liver oil.

In its original form, the concentrate had a restricted usefulness, since it contained much of the bad taste and unpleasant odor of cod-liver oil, but further refinements have made possible the elimination of these disadvantages and have produced a product which can be added to milk without altering its flavor. While we are still dealing with an impure substance, the activity of the more recent concentrates is now approaching that of irradiated ergosterol.

Dr. Barnes, of the Detroit Health Department, has conducted a series of tests with milk so treated on rachitic infants and has found that a quart of milk having 150 units of "vitamin D" (equivalent to 3 teaspoonfuls of cod-liver oil), and also amounts corresponding to about 100 units, give excellent results in the treatment of rickets.

It has also been found practical to add the concentrate to bread, as the vitamin D is not destroyed at baking temperatures. An arbitrary standard of 90 units to a 1-lb. loaf has been temporarily adopted.

An economic advantage of this process lies in the fact that the de-vitaminized cod-liver oil is still suitable for industrial purposes, and can be sold at full price so that the raw material cost of the concentrate is very low.

It was originally taken for granted by those engaged in the development work on the cod-liver oil concentrate that the process would be made freely available to any one who wished to use it, but objections to this plan began to multiply. In the first place, conferences with representatives of drug manufacturers made it clear that no one would undertake the extensive work needed for perfecting production methods and marketing the product unless protected from competitors who could enter the field after the pioneering work was done and secure profits without material outlay. Secondly, it seemed desirable to control the manufacture, application and promotion of the product, so that the public could be protected against improperly treated foods on one hand and false claims on the other.

Finally, the president of Columbia University indicated that he had had in mind for some time the creation within the university of some means of meeting just such situations. At his behest, the Board of Trustees passed a resolution creating a Board of University Patents, which now functions under the name of University Patents, Inc. This board consists of trustees and faculty members and is empowered to accept patent rights and copyrights and administer them for the public good. The vitamin D concentrate process was patented in several countries and the applications were assigned to University Patents, Inc. It was decided that royalties which might accrue were to be used for further research within the university.

License contracts were then entered into between University Patents, Inc., and National Oil Products Company, by which the latter obtained the right to manufacture and sell the concentrate in the United

States, Canada and Newfoundland, while the university undertook strict supervision of all advertising, stipulated control of the quality of the reinforced foods by means of regular assays by independent laboratories, and also maintained certain regulations as to prices to be paid by the public in order to keep these as low as possible. The university's royalty was also kept at a low rate in order to keep the burden on the consumer at a minimum.

Through this arrangement we have hopes of making a useful product available to the public in an efficient manner, at the same time safeguarding the interests of the university. A number of problems have presented themselves, some of which have been successfully met, but new ones are still coming up and await solution. It should be possible to set certain useful precedents.

Theodore F. Zucker
College of Physicians and Surgeons,
Columbia University

TWO CRITICISMS

I desire to call attention to two practices which in recent years are occasionally noticed and which are objectionable. One is the use of the *unit* of wave-length, Å, for the wave-length itself, λ. The other is the putting of zeros in the tens columns of catalogues.

With the adoption of the Ångstrom as the official *name* of the unit of wave-length in the spectrum some writers began to use it in place of λ, the wave-length itself. This is neither logical nor advantageous. The use of λ before the number to designate wave-length had become an established practice, a necessity, and entirely satisfactory. It is by no means my feeling or wish to detract from the honor due the great Ångstrom, merely to clarify the use of this honor, which it seems to me is fairly obvious as the intentions of the body bestowing it.

Before the adoption of the Ångstrom as the unit (as well as since) the wave-lengths were given in ten millionths of a millimeter. Sometimes this unit of length was given as μ, but usually it was assumed to be understood. Now the Ångstrom, Å, is merely the *name* of this *unit* of a ten millionth of a millimeter, but obviously not the wave-length itself, which is the *whole number* of these units which go to make up the wave-length λ.

Those who use Å usually omit λ, as, for example, 4,340 Å instead of λ 4,340. While perhaps correct in a sense it is much as if we gave a certain number of inches and failed to say of what they were the measure. The users of Å in the way criticized will probably counter that it is well known that these are wave-lengths, to which I would reply that for a much longer time it has been known what the unit was.

It seems to me that here is where the fundamental conception is wrong—that the old designation λ is correct and that the unit Å applies only *within* the spectrum to specify the distances between lines or an arbitrary number of units. That when we wish to give the wave-length of Hγ we should say λ 4,340, but that if we wish to give the distance between the two calcium lines H and K we should say 35 Ångstroms instead of 35 ten millionths of a millimeter, or sometimes merely "tenth mu" among spectroscopists, as formerly.

The use of zeros in the tens columns in catalogues is not extensive and I have only noticed it in a few cases comparatively recently. The object presumably is to avoid such mistakes as occur occasionally by a number getting wrongly into the tens columns of such data as right ascensions and declinations or omissions thus causing confusion. Such mistakes happen but seldom; rarely indeed if the proofs have been read with sufficient care. In small lists of very miscellaneous data such a practice may find some justification but not in extensive catalogues, where entire pages often have the same tens column.

My objection to this practice is that not only is it in reality unnecessary, but chiefly that it is a bother to those consulting the catalogues—just that many more figures to take mental note of in getting out the data wanted. Unquestionably, the fewer the figures which the user of a catalogue has to even look at, the better.

As to the number of mistakes which would be avoided by filling in the tens columns with zeros, it can safely be said that they would not offset the work caused in preparing MS, typesetting and proofreading as well as in the use of the catalogues.

One hesitates to make any criticism whatever of some of the finest and most useful catalogues of data ever provided the investigator, but that feeling should not deter us from trying to better even them in small but essential practical matters.

I might add the suggestion that it is becoming increasingly useful to have the epochs at which spectroscopic data were obtained given in the catalogues *as far as possible*. This is usually given in original sources, but where possible it is useful to have such data in general catalogues also.

C. D. Perrine
Cordoba
October 12, 1932

CONCENTRATION OF MICROFILARIAE BY THE SALIVARY SECRETIONS OF BLOODSUCKING INSECTS

During my stay in the Chiapas Mountains, southeast Mexico, in November, 1930, investigating on

behalf of the Mexican Public Health Department the biology and distribution of the simulid flies concerned in the transmission of the microfilariae of *Onchocerca caecutiens,* I made the same observation as Strong in Guatemala on the concentration of microfilaria about the point of the bite and suggested also in my report, read before the III Congress of the Pan-American Medical Association, Mexico City, July, 1931, and published on September 10, 1931,[1] the same method for diagnoses of Onchocera infestation in man, in dissecting engorged simulid flies. It is very interesting to know that Professor Chas. F. Craig[2] has made the same observation with respect to the transmission of *Wuchereria bancrofti* by *Culex quinquefasciatus* in the Philippines. It would be an easy task for medical officers stationed in tropical Africa, where microfilaria-infections are frequent, to add more observations to the reported cases.

ALFONS DAMPF

LABORATORIO ENTOMOLOGICO,
OFICINA FEDERAL PARA LA
DEFENSA AGRICOLA,
SAN JACINTO D. F.,
MEXICO

BULBS FROM HOLLAND

I EXPECT that by now you have learned of the fictitious nature of the "Hollandia's World-Famed Flower Bulbs" advertisement which appeared in SCIENCE in September, and in other American magazines. It was exposed in the Report of the Chicago Better Business Bureau for November 4. According to the report:

A fraud order was issued by the Post Office Department against Bulb Nurseries "Hollandia" and Harry Bruhl, its director at Voorhout by Hillegom, Holland, for fraudulent practices in the sale of flower bulbs. A previous fraud order was issued on March 18 against L. H. Straathof and others of Hillegom, Holland, upon evidence showing that under those names a scheme to defraud was being conducted through United States mails.

From an American bulb grower's view-point, this advertisement is of concern because it mentions the "certificate of health" supposed to accompany these bulbs. As a matter of fact, our great American bulb-growing industry has been made possible through the establishment of quarantine regulations necessitated by diseases harbored in foreign grown bulbs. The better Holland growers have tried to control these troubles but with varying success. Plant disease control largely depends on efficient crop rotation. This important measure is exceedingly difficult in a locality where usable land is limited and has given rise to certain rather artificial methods of culture. For example, it is a Holland custom to attain partial crop rotation by deep spading and turning the soil upside down, thus creating a "new" field. From a phytopathological view-point such methods can not compete with those possible in American bulb areas where land for rotation is unlimited and climatological factors more favorable.

Competent observers have pointed out that the success of the Holland bulb growers is not attributable to favorable climatic and edaphic factors but to the industry of the growers who have overcome unfavorable circumstances by what may be considered artificial methods. These methods have produced fine bulbs, but we feel that out of fairness to American growers it should be pointed out that the standard of American grown bulbs on a disease-free basis is equal to or higher than that which obtains abroad.

FRANK P. MCWHORTER

OREGON STATE COLLEGE

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE "ROTETTE" OR AN APPARATUS FOR HANDLING SMALL QUANTITIES OF LIQUIDS WITH RAPIDITY AND PRECISION

IT was found in using the pipette previously described[1] that even higher precision was attained by mounting the pipette in bearings at a convenient angle. In this arrangement it could be used directly as before or it could be connected to another tube, either fixed or movable, by means of a rubber tubing. This greatly extended the usefulness of the device since larger quantities of mercury could be safely handled, though there was still a limitation due to the weight of the mercury and its tendency to surge when large quantities were employed.

The employment of a helical glass tube in place of the two bulbs previously used greatly simplified the problem and extended the practical limits as to quantities for which it might be adaptable. With the helical tube it is no longer necessary to have a volume of mercury equal to the volume of liquid to be handled, since only enough mercury to fill the lower half of one turn of the coil is required. The controlling factors are diameter of tubing and of coils and the number of turns. A proper choice of these makes it possible to control the volume desired. With this form the volume displacement is proportional to

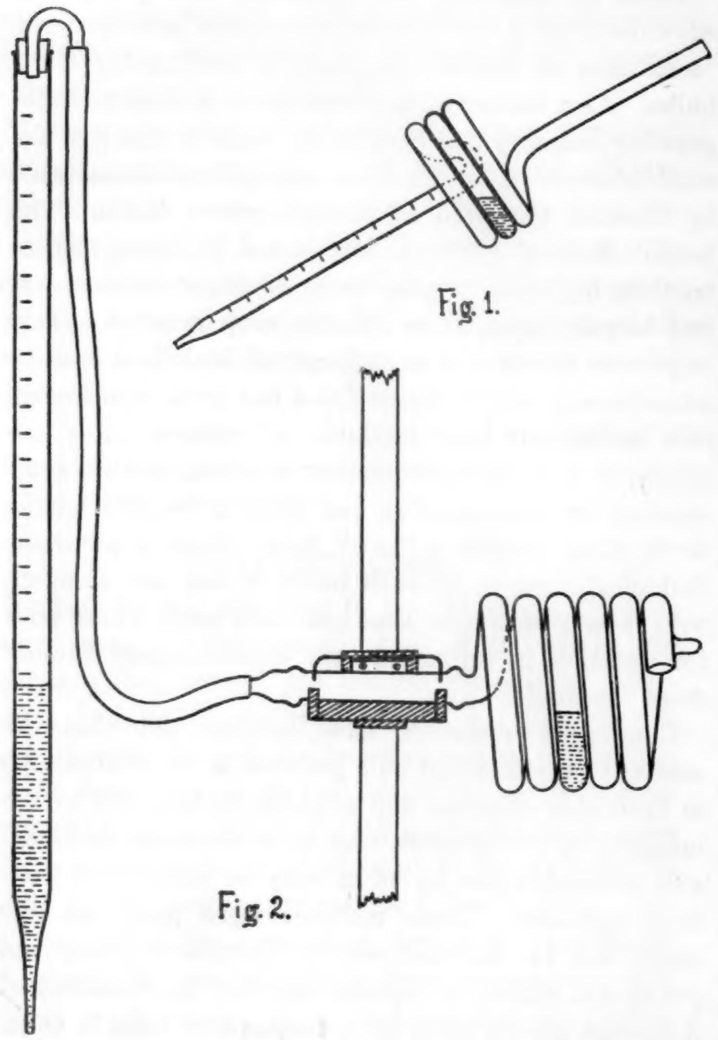
[1] *Medicina, Revista Mexicana:* Vol. xi, Year XII, No. 151, pp. 753–761 (see p. 757).

[2] SCIENCE, 1952, May 27, 1932, pp. 561–2.

[1] E. L. Harrington, SCIENCE, p. 201, Aug. 22, 1930.

the angular rotation and it may be stopped in any position, since it is symmetrical about the axis of the helix.

"Rotettes" of the new form were constructed for hand use, as shown in Fig. 1, and also for mounting



on bearings, as shown in Fig. 2. The advantages of the small form have been discussed.[2] Among these may be mentioned the elimination of the rubber bulb, with all its objections, the necessity of "sucking" directly with the mouth and the difficulty of controlling the outflow of liquid by holding the finger over the upper end of the pipette. In addition may be mentioned the better manual control afforded. It will be observed that the bend leading from the coil to the lower tube is elevated so that the mercury can not run out, even when the pipette is held vertically. In using this form one has merely to hold the rotette at about the angle shown. A rotation in one sense about its axis elevates the liquid, while the reverse rotation ejects it.

When more than a few cubic centimeters are involved, the form shown in Fig. 2 is generally to be preferred. Rotettes with capacities up to 50 cc (but using only 5 or 6 cc of mercury) have been constructed. In this form it has many uses, and a number of advantages over burettes, etc.—among which may be mentioned the following:

(1) It makes for higher precision in operations of the titration type. It is easy to "split" drops without the tedium involved in other methods.

(2) It obviates the use of stop-cocks, pinch-cocks and many other special devices now employed. This is a very important improvement, for leaky cocks, stuck or frozen cocks, contamination by cocks and stop-cock grease, difficulties in cleaning, limitations as to flow, the difficulty of getting "just a drop," are all eliminated.

(3) It eliminates the funnel-bottle method of filling, for the burette is filled directly from the supply container, quickly, and the remnant left after a determination may be returned or ejected just as quickly.

(4) It eliminates the "sucking" of fluids into pipettes, with its dangers to person, and the resulting contaminations by mouth fluids and breath-borne vapors. This makes it possible to put or to hold the rotette in the best position for visibility. The rotating member can be placed in a convenient position, even though the receiving tube has to be introduced into awkward places.

(5) It saves time, since burettes, etc., can be filled to the mark desired without the usual delay or "fiddling." In letting the liquid down, the rate of flow is subject to controlled variation between the full stream of the outlet and a slow dropping. This enables one to "go fast" until he nearly reaches the critical level. It is so easy to restore the liquid to the original level that one need not use long and awkward burettes to avoid having to refill frequently. After practice one learns how much of a turn is required in a certain test. Another great saving in time is gained in the cleansing of the burettes, since the absence of stop-cocks makes cleaning a simple matter. By the same operations cleaning solutions, distilled water, etc., can be introduced without even taking down the burette. When burettes are filled the old way, one has to wait until the liquids have drained down in order to avoid a zero error—with the rotette the surface need not be raised above the zero. With the old method it takes so much time to get the surface just to a mark that students are often tempted to call it "good enough" and to try to carry corrections in the mind. With the rotette a quick adjustment to a line is possible.

(6) It lessens the dangers of contamination. In addition to the points mentioned above it is obvious that stop-cock grease is soluble in many liquids one might want to handle, and in any event one can hardly know when a stop-cock has been really cleaned.

[2] *Loc. cit.*

With stop-cocks, pinch-cocks, rubber tubing, etc., eliminated, one has merely an open tube to clean. The burette is never open at the top to catch contaminating solids or fumes, and no funnels are needed.

(7) It can be used for liquids too viscous to flow readily through a stop-cock, *e.g.*, agar agar—which must often be handled in measured quantities, and handled at a temperature where stop-cock grease would become thin. With the rotette the lower outlet can be made a size suited to the liquid and to the speed employed. The rotette can be used equally well with liquids which attack either stop-cock grease or the ground surface of the glass itself, such as, *e.g.*, KOH or NaOH which so often cause cocks to freeze.

(8) A rotette can not wear out—and while in use it saves the price of a stop-cock on every burette with which it is employed. The burettes without stop-cocks are not only cheaper, but are less fragile—for most of the breakages of burettes are due to stop-cock troubles rather than to accidents. One of these mounted over a stock bottle might facilitate obtaining the definite quantities that may be required in routine tests.

(9) It can be used in places where stop-cocks would be inaccessible, as well as in hot, corrosive or poisonous liquids.

It would appear that the rotette is especially well suited for all types of burette and pipette work, for rapidly measuring out fixed quantities of liquids for routine tests in chemical, biological and clinical laboratories. As the movement is wholly rotational it lends itself to mechanical operation as a rack and pinion arrangement provided with stops would adapt it to the commercial or laboratory filling of vials with definite quantities of liquid. Or, similarly, it could be arranged for foot control in which case both hands would be free for other operations, which would be a very great advantage in many situations.

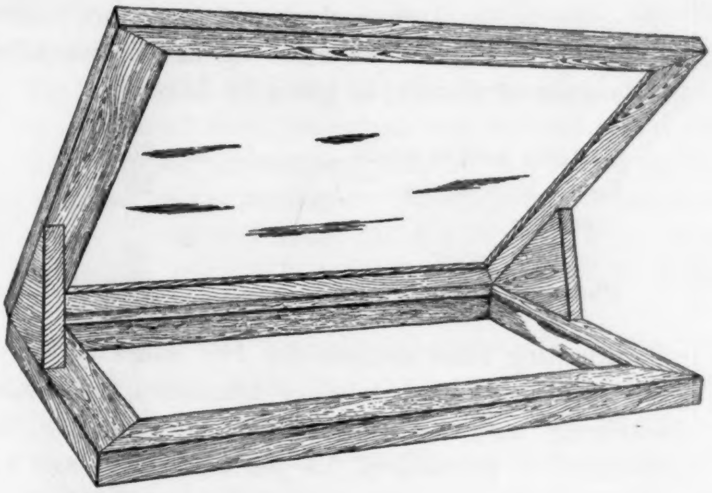
Suggestion: When connecting the rubber tubing to the burette the mercury should be in the middle coil, as this minimizes the twist that must be given the former in use. The tubing should be one of the smaller commercial sizes, preferably heavy walled to prevent kinking.

E. L. HARRINGTON

UNIVERSITY OF SASKATCHEWAN,
CANADA

MIRROR DEMONSTRATION APPARATUS

IN many lecture rooms the top of the instructor's table is above the line of vision of persons seated in the audience. Demonstrations which must remain flat upon the table are therefore often out of sight of, or at best imperfectly seen by, observers in the lecture room. The difficulty attendant upon demonstrating certain materials to large groups of students can be overcome by the device represented in Fig. 1.



A wooden frame holds a mirror at an angle with the table top. The object to be demonstrated is placed inside the base of the frame under the mirror; the reflected image is then visible to students seated in all parts of the room. The angle of the mirror will be determined by the height of the table top above the horizontal line of vision of the audience. In our laboratory, a mirror (size 40×50 cm) held at a 40° angle gives good results with groups of seventy students. Spot lights may be directed upon the demonstration area from the sides or from above without interfering with the visibility.

The apparatus is particularly useful in demonstrating artificial "amoeboid" action induced by the interaction of various chemicals; in these experiments it is essential that the dishes remain stationary and in a horizontal position. The apparatus is also useful in showing the peculiar movement of waltzing mice; other uses will doubtless suggest themselves to the reader.

The writer is indebted to the department of graphics in Dartmouth College for the perspective drawing in Fig. 1.

W. BYERS UNGER

DARTMOUTH COLLEGE

THE USE OF PHENOSAFRANIN FOR STAINING FUNGI ON CULTURE MEDIA OR IN HOST TISSUE

THE work of Mangin (1890) first brought out the use of phenosafranin as a differential stain for pectose and lignin. This stain is frequently used in dilute aqueous solution as a desensitizer for panchromatic film. It gives a dark red color in the alkaline condition, which may be removed by means of alcohol or an acid alum solution. This stain has been found useful in mycological studies for both fresh and preserved material and also in the examination of bacterial colonies growing on an agar substratum.

In order to avoid plasmolysis and to restore turgor to the cells the stain was made up in solution after the formula of Satory, as given by Linder:[1]

Carbolic acid crystals	20	gms.
Lactic acid, syrup	20	"
Glycerine	40	"
Distilled water	20	"
Phenosafranin	0.5	" or less

Mordanting fixed sections for two hours with a 2 per cent. iron alum solution intensifies the stain. Destaining may be accomplished by washing the material in a solution of 0.5 per cent. alum and 0.5 per cent. HCl or by means of alcohol. After destaining it is often desirable to set or intensify the stain by applying a 1 per cent. ammonium hydroxide solution. For use in the examination of mycelia in host tissue, the destaining of the parenchymatous tissue is more rapid than that of the parasite, so that by proper control of this process a differential stain may be attained. Sections of Johnson grass leaves infected with a rust stained for twenty minutes in phenosafranin and then destained for ten minutes in acid alum show a differential stain between host and parasite tissue. In the case of mycelia within woody tissue the contrast is not so pronounced, since the lignified walls retain the stain as well as the mycelia.

This stain has proved particularly adaptable in the study of bacterial and fungal colonies growing on an agar substratum. If these colonies be treated with phenosafranin the medium does not absorb the stain as readily as the cells, so that the latter stand out intensely stained against a lighter background, no destaining being necessary.

Phenosafranin is superior to the cotton blue suggested by Linder, because the red is a more intense stain than the blue and also because of the much greater permanence of the phenosafranin color

ELIZABETH JANE MOORE

DEPARTMENT OF BOTANY
AND BACTERIOLOGY,
UNIVERSITY OF TEXAS

SPECIAL ARTICLES

PROTEIN FRACTIONS OF THE H 37 (HUMAN) STRAIN OF TUBERCLE BACILLUS[1]

THE method of protein fractionation[2] recently used in the case of the timothy grass bacillus[3] has now been applied to a human strain (H 37) of the tubercle bacillus.

A frozen and dried harvest of the organism[4] (grown on Long's medium) was extracted in the cold with acetone and ether, ground in a ball mill and again extracted, as described previously.[3] The cell residues were stirred for about 6 hours in the cold successively with buffer at pH 4.0 (fraction C), buffer at pH 6.5 (fraction D), water containing enough *N* NH_4OH to keep the pH at 8.3–8.5 (E), water made alkaline to about pH 9 (F), and water made alkaline to about pH 11 (G). The residual material was stirred in turn with 0.1, 0.2 and 0.5 *N* NaOH at room temperature (K, K′, K″). The properties of the fractions obtained by acidifying two lots of the extracts are given in the table. Each fraction was redissolved and reprecipitated twice.

Fraction	$[\alpha]_D$ degrees	N Per cent.	P Per cent.	Basic ash Per cent.	Precipitin reaction of 1: 2000 solution with anti-human strain serum[4]	Precipitin reaction of 1: 2000 solution with anti-timothy bacillus serum[4]
701						
D	+ 9	15.7	3.4	0.7	±(±)*	– (+)
E	+11	15.4	2.0	0.5	±(±)	
F	–26	15.0	1.8	1.4	±(±)	±(+)
G	–31				±(±)	±(±)
K	–61	16.2	0.4	0.4	±(±)	+(+±)
K′	–50	14.9	0.04	0.3	±(+)	+(+)
K″	–18	11.2		1.9	+++(++++)	+(+±)
702						
D	+ 9	15.6	3.7	0.8	±(±)	+(+±)
E	–19	15.8	2.1	0.2	±(±)	+(++)
G	–28	15.7	2.1	0.2	±(±)	+(++)
K	–56	15.3	0.6	0.3	±(+)	+(+)
K′	–51	15.3	0.06	0.2	±(+)	+(+)
K″	–46				+++(++++)	+(++)

$[\alpha]_D$, N, P calculated to ash-free basis.
* Values in parentheses obtained after centrifugation

As in the case of the corresponding fractions of the hemolytic streptococcus,[2] levorotation increases and

[1] David H. Linder, "An Ideal Mounting Medium for Mycologists," SCIENCE, 70: 430, 1929.

[1] From the Department of Medicine, College of Physicians and Surgeons, Columbia University and the Presbyterian Hospital, New York City.

Carried out under a grant from the National Tuberculosis Association and with the aid of the Harkness Research Fund, Presbyterian Hospital, New York City.

[2] M. Heidelberger and F. E. Kendall, *Jour. Exp. Med.*, 54: 513, 1931.

[3] M. Heidelberger and A. E. O. Menzel, *Proc. Soc. Exp. Biol. and Med.*, 29: 512, 1932.

[4] Kindly supplied by the H. K. Mulford Biological Laboratories of Sharp and Dohme, Glenolden, Pa.

phosphorus decreases in general from the D to the K fraction. The percentage of nitrogen, however, remains nearly constant throughout the present series. The exceptional properties of the very small K″ fraction appear due to contamination with specific polysaccharides,[5] especially since the other fractions are practically inactive toward an immune serum known to be rich in polysaccharide antibodies. The products differ in this respect from Johnson's "water soluble" and "alkali-soluble" tubercle bacillus proteins.[6] The relationship of the new fractions to the three proteins indicated by Levene[7] will be investigated.

The somewhat stronger precipitin reactions given by the fractions in an anti-timothy bacillus serum than in the homologous antiserum indicate that all contain group-specific protein. The only additional biological data available at the present preliminary stage of the study are that a proportion of normal rabbits showing a negative skin test to fraction K respond with a "lighting up" of the original test area during a subsequent course of intravenous injections of K, and, as found by Sabin and Smithburn at the Rockefeller Institute for Medical Research, a distinct difference in the type of skin reaction produced by the D and K fractions in tuberculous guinea pigs.

MICHAEL HEIDELBERGER
ARTHUR E. O. MENZEL

INDUCTION OF EXPERIMENTAL GRANULAR CONJUNCTIVITIS BY DIRECT INOCULATION OF TRACHOMATOUS TISSUE

IN a recent review on the causation of human trachoma Dr. Bengtson[1] writes: "If it can be shown that the condition produced in *Macacus rhesus* monkeys by direct transfer from cases of human trachoma is as definite and as easily transmissible as that induced by inoculation with *Bact. granulosis*, then we would feel more certain of the relationship of *Bact. granulosis* to the human disease."

The observations herein reported demonstrate that direct transfer from such human cases is definitely and easily made and no difference exists between the readiness with which the experimental granular conjunctivitis can be induced by means of human tissue and culture of *Bact. granulosis*.

Through the kind cooperation of Dr. Martin Cohen, of New York, we obtained recently the tarsectomized conjunctival tissue removed for curative purposes from a case of florid trachoma of three years' duration, accompanied by bilateral pannus.

[5] M. Heidelberger and A. E. O. Menzel, *Proc. Soc. Exp. Med. and Biol.*, 29: 631, 1932.
[6] T. B. Johnson, *Am. Rev. Tuberc.*, 14: 169, 1926.
[7] P. A. Levene, *Medical Record*, Dec. 17, 1898.
[1] I. A. Bengston, Public Health Rep., 47: 1914, 1932.

The specimen was employed in two ways: (a) For direct subconjunctival injection of one eye of monkeys having smooth lids, and (b) for bacteriological study. A culture of *Bact. granulosis* was isolated and it also was injected subconjunctivally in one lid of normal *Macacus rhesus* monkeys. Thus human trachomatous tissue, on the one hand, and a culture of *Bact. granulosis*, on the other, both having a common origin, were used to inoculate monkeys.[2]

The first two animals injected with the culture showed within seven days characteristic granular conjunctivitis in the inoculated eye. Within another week, the uninoculated conjunctivae became similarly affected, and after three weeks, the experimental disease, previously described in detail,[3] was fully developed. Conjunctival tissue was removed from one of the affected animals two weeks after inoculation, and employed for subconjunctival injection of two fresh monkeys; they in turn were apparently affected in the same way as the preceding animals. In this manner, monkey to monkey transmission was obtained through seven passages. At this point, when we were convinced that transfer could be carried on indefinitely, the experiment was terminated.

The first two animals inoculated with the suspension of human trachomatous tissue exhibited, within seven days, characteristic granular conjunctivitis, and again the tissue of one of them induced the experimental disease in two fresh animals. The affection was thus transmitted through seven consecutive series, at least, of paired animals. The period of incubation, the conveyance of infection from inoculated to uninoculated eye, the appearance of the early and fully developed lesions of the disease and the histopathological changes were identical with those shown by the animals of the culture series.

The activity of the incitant in both series apparently became "fixed" in the consecutive transmissions, that is, the incubation period and the degree of reaction became constant.

Since transfers were made early in the course of the affection, we were able to study the microscopic changes of beginning conjunctival lesions. These consisted of congestion of blood vessels and marked hypertrophy of their endothelium. The vessels were surrounded by a thick layer containing chiefly monocytes, some lymphocytes, and a few polymorphonuclear cells with acidophilic granules. In later stages, the perivascular agglomerations were coalesced to form the large folliculomata characteristic of trachomatous lesions.

[2] All operative procedures were carried on with the aid of ether anesthesia.
[3] H. Noguchi, *Jour. Exp. Med.*, 48, Suppl. 2, 53 pp. 1928; P. K. Olitsky, R. E. Knutti and J. R. Tyler, *Jour. Exp. Med.*, 53, 753, 1931; 54, 31, 1931.

Finally, cultures of *Bact. granulosis* were isolated from monkeys of the first and second passages of the series of transmissions initiated by inoculation of trachomatous tissue, and from animals of the third and sixth passages of the *Bact. granulosis* series.

In conclusion, we have found that the experimental disease induced by human trachomatous tissue is as definitely transmissible as that produced by cultures of *Bact. granulosis,* and that from different animals of both series the microorganism can be recovered. We also record the fixed character of the incitant in consecutive animal passages and the anatomical changes of early experimental lesions.

PETER K. OLITSKY
JEROME T. SYVERTON
JOSEPH R. TYLER

THE ROCKEFELLER INSTITUTE
FOR MEDICAL RESEARCH,
NEW YORK

ROD-SHAPED PARTICLES IN TOBACCO MOSAIC VIRUS DEMONSTRATED BY STREAM DOUBLE REFRACTION

FOR some years pathologists have been attempting to obtain evidence regarding the nature of the filterable viruses which cause numerous diseases of man, lower animals and plants. Although much information has been gained regarding the properties of viruses the available evidence is still insufficient to prove whether the virus particles are inanimate colloids or organisms which are too small to be seen through the microscope.

We have recently attempted to obtain evidence regarding the shape of virus particles by the use of polarized light. Methods somewhat similar to those described by Ambronn and Frey[1] and Freundlich[2] for determining the shape of colloid particles have been used in this work. According to these workers minute isotropic rods, disks or leaf-shaped particles contained in a flowing liquid tend to become oriented with their long axis parallel to the direction of flow. Under these conditions a liquid containing rods is doubly refractive when the direction of transmission of the incident light is perpendicular to the direction of flow; a liquid containing disks or leaf-shaped particles is doubly refractive when the incident light is perpendicular to the direction of flow and parallel to the faces of the particles. This so-called form double refraction only occurs when the dispersed phase has a refractive index which differs from that of the continuous phase and when the shortest axis of the particle is small in relation to the wave-length of the light used. Liquids containing anisotropic rods, disks or leaf-shaped particles also show form double refraction under the above conditions, and in addition to this may show an intrinsic double refraction due to the arrangement of atoms in the particles. This intrinsic double refraction occurs when the anisotropic particles are so oriented that their long axis is parallel to the direction of flow, and the direction of transmission of the incident light is not parallel to the optic axis of the particles. Since most of the studies which have been made on virus particles indicate that they are smaller than the wave-lengths of visible light it appears that if virus particles were to have the form of rods, disks or leaves, and the proper refractive index, and were in sufficient concentration, the flowing virus suspension should show double refraction.

In order to test this idea the apparatus shown in Fig. 1 was set up. It consists of an ordinary microscope lamp L and a microscope stand S, from which

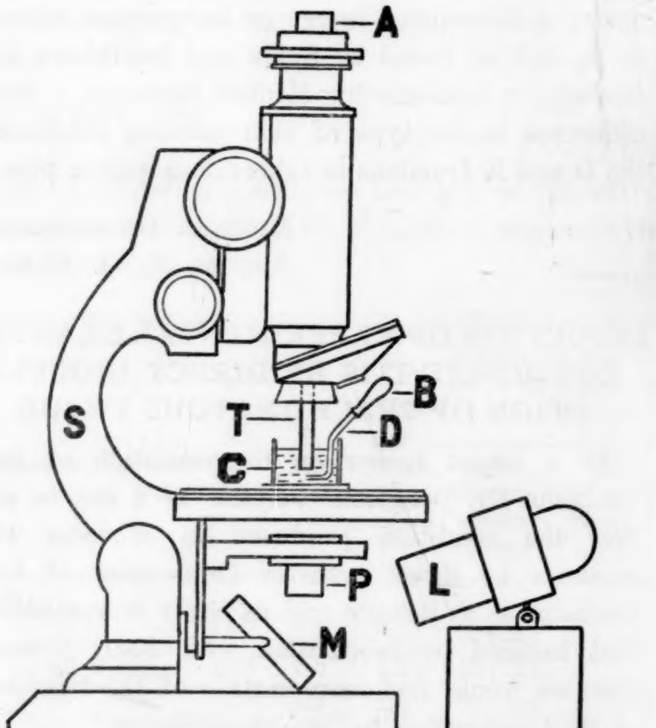


FIG. 1. Apparatus used to detect stream double refraction in virus-containing plant juices and other sols.

the ocular, objectives and condenser have been removed. A polarizer P was placed in the diaphragm carrier and an analyzer A was attached to the microscope tube. A curved glass pipette D, having an inside diameter of 0.5 mm at the orifice, was prepared. This was cemented to the inside of a cylindrical glass chamber C, with its orifice so directed that pressure on the bulb caused a stream to flow across the middle of the chamber. A small round cover glass was cemented to the lower end of the glass tube T, and the upper end of the tube was pushed through a hole in a rubber stopper. The stopper was held in one of the

[1] H. Ambronn and A. Frey, "Das Polarisationsmikroskop." Leipzig. 1926.

[2] H. Freundlich, "Colloid and Capillary Chemistry." E. P. Dutton and Co., New York.

sockets in the nose piece. The glass tube T, the peripheral portion of the cover glass and the lateral surface of the vessel C were painted with black paint so that only light from the polarizer passed up through tube T. The polarizer was turned on its vertical axis until its vibration direction made an angle of 45° with the direction of flow of the liquid expelled from the pipette. The analyzer was then turned until the field was dark as a result of the nicol prisms being crossed.

Leaves of tobacco plants affected with typical mosaic (Johnson's tobacco virus 1) were frozen at 0° F. for 15 hours. The leaves were then thawed at room temperature for about 1 hour and the juice was pressed out of the leaves by means of a screw press. The juice was centrifuged and about 5 cc of the supernatant liquid were poured into the chamber C. A small volume of the liquid was then drawn up into the pipette by means of the rubber bulb B. Upon pressing the bulb while looking through the analyzer the liquid flowing from the pipette was seen to be distinctly doubly refractive, and appeared as a bright streak across the dark field, as seen at A in Fig. 2.

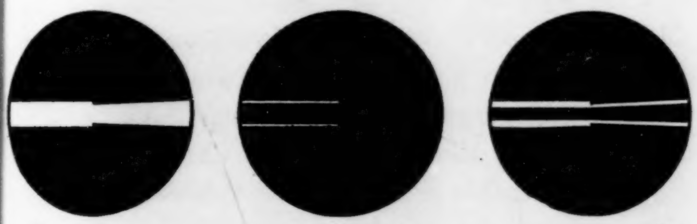


FIG. 2. Showing the appearance of the field when different liquids were expelled from the pipette.

A = Field produced by solutions known to contain rod-shaped particles and by virus-infected plant juice.

B = Field produced by juice from healthy plants.

C = Field produced by ferric oxide sol containing disk-shaped particles.

Juice from healthy leaves prepared in the same way showed no detectable double refraction, the field appearing dark as shown at B in Fig. 2. This experiment was repeated 6 times, with leaves from 6 different healthy and mosaic tobacco plants, once with juice from the roots of a healthy and mosaic tobacco plant, and once with juice from the leaves of a healthy and mosaic tomato plant. In each case double refraction was shown only by juice from the mosaic plants.

Freundlich[2] has reported that sols of vanadium pentoxide, aniline blue and benzopurpurin have rod-shaped particles, while old ferric oxide sols have disk-shaped particles. In order to gain evidence regarding the shape of the particles in the virus-bearing juice which are responsible for the double refraction, sols of vanadium pentoxide, aniline blue, benzopurpurin and ferric oxide were tested in our apparatus. It was found that, like the virus-bearing juice, the sols containing rod-shaped particles produced a stream which showed uniform light intensity throughout the width of the stream as shown at A in Fig. 2. On the other hand, the ferric oxide sol containing disk-shaped particles produced a stream which showed double refraction only along its edges as shown at C in Fig. 2. This behavior is presumably due to the fact that it is only in the edges of the stream that a large proportion of the disk-shaped particles are oriented with their faces parallel to the direction of transmission of the incident light.

It has not been determined whether the double refraction observed in the infective juice is a form double refraction, an intrinsic double refraction or a combination of both types. In any case the occurrence of stream double refraction in the juice of mosaic tobacco plants, its absence in the juice of healthy plants and its similarity to the stream double refraction shown by sols containing rod-shaped particles, indicate that the virus of tobacco mosaic or some substance regularly associated with it, is composed of rod-shaped particles.

WILLIAM N. TAKAHASHI
T. E. RAWLINS
DIVISION OF PLANT PATHOLOGY,
UNIVERSITY OF CALIFORNIA,
BERKELEY

PHOTOCHEMICAL NITRIFICATION IN SEA WATER

SINCE nitrates frequently are considered to be a limiting factor in the productivity of the sea, phenomena which increase the available nitrogen for plant growth are of great importance. It has been tacitly assumed by many authors that the same biological agencies which are operative in the transfer of nitrogen from one form to another in the soil similarly activate these processes in the sea. However, Lipman,[1] Atkins,[2] Brandt[3] and other investigators have reported their failure to demonstrate nitrifying bacteria in the open seas, although nitrifiers are frequently found near the shore and in bottom muds. Similar observations in the Pacific Ocean off the coast of California in the vicinity of San Diego have been made repeatedly by the writer. Brandt has mentioned the possibility of nitrites being formed from ammonium near the surface, due to the presence of inorganic catalysts in the sea water.

It has been impossible to demonstrate nitrifying bacteria by the conventional soil methods when from 0.1 to 100 cc of sea water was inoculated into Winogradsky's solution and other similar nutrient com-

[1] SCIENCE, 56: 501, 1922.

[2] *Jour. du Conseil*, 1: 197, 1926.

[3] *Wissensch. Meeresuntersuchungen*, 20: 203, 1927.

binations, although controls inoculated with a little garden soil or even sea bottom muds have given positive results. There was no perceptible nitrification in media consisting of raw sea water to which ammonium salts were added in different concentrations. Varying the temperature from 4° to 30° C. by six-degree intervals did not give any evidence of the presence of nitrifiers in the sea water.

On the other hand, soil nitrifiers, *nitrosomonas,* failed to elaborate any nitrites when inoculated into sea water with the addition of magnesium carbonate in excess and ammonium sulfate, although they were still viable after eight weeks at 20° C. In a medium consisting of 50 per cent. sea water and 50 per cent. Winogradsky's solution inoculated with *nitrosomonas,* nitrification occurred, but not as readily as in straight Winogradsky's solution. With 75 per cent. sea water the amount of the reaction was negligible and 90 per cent. sea water stopped it. The addition of 5 to 10 per cent. sea water to Winogradsky's solution accelerated the oxidation of ammonium to nitrites by the biological agents mentioned above. Such evidence seems to warrant the conclusion that if bacterial nitrifiers are in the open seas, they are different from the soil forms, but it does not preclude the possibility of there being bacterial nitrifiers in the sea which require special methods of cultivation. Investigations are now in progress which may help to elucidate this point.

In continuing the inquiry into the mode of origin of nitrates, it was found, contrary to expectation, that sunlight favored nitrification in sea water under certain conditions. When pyrex flasks partly filled with raw sea water plus 0.005 per cent. ammonium sulfate were exposed to light on the top of a building for two weeks there was a measurable increase in nitrites as well as nitrates and a corresponding decrease in the ammonium content. The controls in the dark were unchanged. Examinations revealed that there were fewer viable bacteria in the flasks which had been exposed to sunlight than in the dark controls. The removal of bacteria by filtering the water through a Berkefeld N candle into sterile flasks did not influence the oxidation of ammonium to nitrites when thus irradiated. The reaction was accelerated by the addition of manganese dioxide. No perceptible oxidation of ammonium occurred in distilled water nor in artificial sea water under comparable conditions. Autoclave sterilization (120° C. for 30 minutes) of sea water destroyed its photochemical nitrifying properties. This is attributed to the thermal destruction of certain oxidizing substances or even organic catalysts.

Many of the above experiments were repeated, using ultra-violet light having a maximum intensity in the 2950Å region. Such irradiation of sea water mixtures produced results not unlike those observed under the influence of sunlight, except for the speed of the reaction. Exposure to the mercury arc at thirty inches for two hours caused the oxidation of as much ammonium as the daylight did in two weeks. Again it was found that more ammonium was oxidized to nitrites by irradiation of sea water than distilled water. Ultrafiltration of sea water did not alter it in this respect, but autoclaving it retarded the reaction. Increasing the intensity of the irradiation ten times by bringing the source to within about 9½ inches from the test solutions actually caused the destruction of more ammonium than could be accounted for as nitrites or nitrates.

In view of these observations it appears that at least part of the nitrification which occurs in the sea is photochemically activated. Zolcinski[4] has repeatedly found that chemical nitrification in the soil is activated by sunlight in the exclusion of biological agencies. It is well known that under certain conditions ultra-violet light causes the oxidation of ammonium to nitrites. Due to the slight penetrability of water by these rays, they could play an important rôle only at or a few millimeters from the surface. Inasmuch as no light filters were used in these preliminary tests, many rays other than the ultra-violet may have been the effective ones. The mercury arc did supply visible light of great intensity. As previously stated, the solar rays responsible for the reaction will pass through pyrex glass. The point to be emphasized at this time is not which rays are active, but rather that the irradiation of sea water causes the oxidation of ammonium to nitrites and that sunlight supplies the necessary rays. In a later communication a report of the foregoing experiments will be amplified and additional observations given.

C. E. ZoBell

SCRIPPS INSTITUTION OF OCEANOGRAPHY
UNIVERSITY OF CALIFORNIA
LA JOLLA, CALIFORNIA

BOOKS RECEIVED

Annual Report of the Director of the National Park Service, 1932. Pp. 100. Illustrated. National Park Service, U. S. Department of the Interior.

JOHNSTONE, JAMES and R. J. DANIEL, Editors. *Report for 1931 on the Lancashire Sea-Fisheries Laboratory, University of Liverpool, and the Annual Report of the Marine Biological Station, Isle of Man.* Pp. 169. Illustrated. University Press of Liverpool. 6s.

Journal of the Faculty of Science of Hokkaido Imperial University. Series IV: *Geology and Mineralogy,* Vol. I, Nos. 3–4. Illustrated. The University, Sapporo, Japan.

Proceedings of the American Council of Learned Societies. Bulletin No. 18. Pp. 152. The Council, Washington, D. C.

[4] *Int. Rev. Sci. Pract. Agric.,* 2: 838, 1924 (Abstract).